WCH-50
Rev. 1

River Corridor Closure Contract

Final Hazard Categorization for the Remediation of the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Solid Waste Burial Grounds

November 2006

Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor

Washington Closure Hanford

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Final Hazard Categorization for the Remediation of the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Solid Waste Burial Grounds

November 2006

Author:

T. J. Rodovsky
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Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
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EXECUTIVE SUMMARY

This report presents the final hazard categorization (FHC) for the remediation of the 118-D-1, 118-D-2, and 118-D-3 Burials Grounds located within the 100-D/DR Area of the Hanford Site and the 118-H-1, 118-H-2, and 118-H-3 Burial Grounds located within the 100-H Area of the Hanford Site. The 118-D-1, 118-D-2, and 118-D-3 Burial Grounds are located within the 100-DR-2 Operable Unit, and the 118-H-1, 118-H-2, and 118-H-3 Burial Grounds are located with the 100-HR-2 Operable Unit. A material at risk calculation was performed that determined the radiological inventory for each burial ground to be *Hazard Category 3*. Because the initial hazard categorization was determined to be *Hazard Category 3* for each of the sites, the development of an FHC was required. This resulted in an FHC of *below Category 3* as a result of the analysis presented in this document. This FHC determination concludes that no activity/process authorized under this FHC could credibly result in undue risk to workers, the public, or the environment.

This analysis includes the following:

- A description of the remediation activities to be performed at the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds

- An assessment of the inventories of radioactive and other hazardous materials within the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds

- Identification of the hazards associated with the remediation activities performed within the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds

- Identification of those accident scenarios with the potential to produce local significant consequences during remediation of the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds

- An FHC based on the physical and chemical form of the radionuclides and the available dispersive energy sources for the burial ground and its hazardous materials

- Identification of special controls derived from the assumptions made in the FHC that are required to ensure that the FHC remains valid

- Identification of project-specific controls established for the protection of the workers that apply specifically to the activity under consideration.

For hazardous chemicals identified during remediation, the sum of the ratios did not exceed 1 (one) for either 29 *Code of Federal Regulations* (CFR) 1910.119 or 40 CFR 68.130 thresholds. The FHC for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Project was determined based on a comparison of the radiological material at risk with adjusted DOE-STD-1027 (DOE 1997) threshold quantities. The Category 3 threshold quantities were adjusted based on the credible release fractions associated with remediation activities. This analysis has determined that the FHC for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Project is below Category 3 (sometimes referred to as "radiological"). To ensure that the conditions assumed in the hazard analysis are maintained, the controls, commitments, and any conditions of approval in the safety evaluation report shall be incorporated into the project's readiness assessment to be completed prior to commencement of the work.

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REVISION HISTORY

Revision	Date	Reason for revision	Revision initiator
0	February 2006	Initial issuance	NA
1	November 2006	Sections 3.14, 4.4, 4.7.2, 4.7.3, 4.7.4, and 5.2 were revised to incorporate comments received from DOE/RL in CCN 127946. Section 3.17 revised to change container payload to a maximum of 25 tons. Sections 4.4 and 5.1 werer revised to changes the method of controlling the inventory of spent nuclear, as authorized by CCNs 126145 and 127554. Sections 4.8 and 5.2 were revised with a new nuclear criticality evaluation, as authorized by CCN 127554. Section 4.9 was revised to evaluates all accident scenarios rather than the most significant ones. Document title was revised. Discussion of Management of Change process was replaced with discussion of Hazard Categorization Evaluation process, throughout. References to BHI procedures were replaced with WCH procedures, throughout. Minor editorial changes throughout.	J. D. Ludowise

ACRONYMS

ALARA	as low as reasonably achievable
AOC	area of contamination
ARF	airborne release fraction
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FHC	final hazard categorization
FSB	Fuel Storage Basin
HMS	Hanford Meteorological Station
MAR	material at risk
OU	operable unit
PMII	Project Managers' Implementing Instructions
PPE	personal protective equipment
RadCon	Radiological Control
RA	remedial action
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR/RAWP	remedial design report/remedial action work plan
RF	release fraction
ROD	Record of Decision
RV	release valve
SAP	sampling and analysis plan
SNF	spent nuclear fuel
TQ	threshold quantity
Tri-Party	*Hanford Federal Facility Agreement and Consent Order Agreement*
WCH	Washington Closure Hanford

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

1.0 INTRODUCTION

This document examines the hazards, identifies appropriate controls to manage the hazards, and documents the final hazard categorization (FHC) and commitments for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Project. The FHC is based on the hazards associated with natural phenomena and remediation activities to be conducted at the burial grounds. The remediation activities analyzed in this FHC are those described in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2005), augmented with those activities associated with the removal, packaging, and transport of discovered spent nuclear fuel (SNF) elements.

1.1 PURPOSE

This report accomplishes the following:

- Describes the activities to be performed during remediation of the waste sites addressed by this FHC
- Assesses the inventory of radioactive and other hazardous materials associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds
- Identifies internally and externally initiated accident scenarios with the potential to produce significant local consequences during remediation of the burial grounds
- Determines an FHC based on a comparison of the material at risk (MAR) with DOE-STD-1027 (DOE 1997) Category 3 threshold quantities (TQs), revised to reflect the credible release fractions (RFs) for remediation activities
- Identifies the necessary controls to manage the hazards and to ensure that the FHC remains valid.

1.2 DOCUMENT ORGANIZATION

Section 1.3 describes the project activities that will be authorized by approval of this document. Section 1.4 describes how configuration and change control will be managed to maintain compliance with the requirements of this document. Section 1.5 summarizes the conclusions and project-specific controls. Section 1.6 describes the overall approach used in the FHC process. Section 2.0 provides the background information necessary to understand the hazards that have potential consequences to workers, the public, or the environment. Section 3.0 provides the basis of operations that are analyzed and authorized under the FHC. Section 4.0 identifies the hazards present, analyzes the identified hazards, and provides the FHC. Section 5.0 describes special, project-specific, and programmatic controls needed to ensure the FHC remains valid and to ensure that workers, the public, and the environment are adequately protected from hazards.

Appendix A identifies the inventory of hazardous substances, sources of energy, and nonroutine hazards unique to the site. Appendix B identifies a systematic examination of the hazards that could potentially lead to a release of hazardous substances, ranking of events, and administrative controls that serve to eliminate or reduce the frequency of these events and to mitigate the consequences. Appendix C provides the quantitative accidents analysis, defines the potential impacts of the site based on a bounding, unmitigated release of radioactive material, and provides the revised TQs, which form the basis for the FHC.

1.3 AUTHORIZED ACTIVITIES

The scope of this document involves evaluating the hazards associated with the remediation activities at the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds. The remediation activities include the following general activities, which are further described in Section 3.0.

- Excavation of soils/sediments, debris, and waste materials (includes field surveys)
- Material handling, sorting, and transportation
- Waste treatment and volume reduction
- Soil and waste characterization and analysis
- Remediation verification
- Identification, characterization, evaluation, accumulation, treatment, and packaging of discovered waste anomalies
- SNF characterization, storage, packaging, and transportation
- Spill cleanup
- Decontamination
- Placement of backfill
- Treatment of mercury
- Stabilization of liquids
- Demobilization.

1.4 FINAL HAZARD CATEGORIZATION EVALUATION PROCESS

Established configuration/change control processes are in place that require evaluation of proposed changes or discovered conditions that affect the assumptions, controls, or other commitments as identified within this FHC. If these commitments are violated, work will cease so that stabilization and/or recovery actions may be identified and implemented, as appropriate. Washington Closure Hanford (WCH) off-normal event procedures describe the reporting process and protocol applicable to such a discovery. NS-1, *Nuclear Safety Manual*, NS-1-2.1, "Hazard Categorization," defines the FHC evaluation process for facilities that have an FHC of "below Category 3."

1.5 SAFETY SUMMARY

Following a detailed analysis of the potential hazards that could be encountered while remediating the burial grounds, it was determined that no activity/process authorized by this FHC could credibly result in undue risk to workers, the public, or the environment (see Section 4.0). Controls that are special in regard to the assumptions made in the FHC are detailed in Section 5.1. Project-specific controls are detailed in Section 5.2, and programmatic controls are detailed in Section 5.3.

1.6 HAZARD CATEGORIZATION

The FHC for the remediation of the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds was determined to be below Category 3 (sometimes referred to as radiological). The FHC (Appendix C) for the burial grounds was determined using the total radionuclide inventories and the Category 3 TQs from DOE-STD-1027 (DOE 1997) revised to reflect credible RFs.

2.0 BACKGROUND INFORMATION

The 100-D/DR and 100-H Areas are located along the northern boundary of the Hanford Site (Figure 2-1), with its northern border delineated by the southern bank of the Columbia River. The 100-D/DR Area contains two of Hanford's surplus nine plutonium production reactors, and the 100-H Area contains one of Hanford's surplus nine plutonium production reactors. Over the years, these reactor facilities released liquid effluents to the soil surface, the soil column, and to the groundwater. As was the case with all of the reactors, solid wastes from 100-D/DR and 100-H Area operations were deposited in designated burial grounds, such as the 118-D-1, 118-D-2, and 118-D-3 Burial Grounds located in the 100-DR-2 source operable unit (OU) and the 118-H-1, 118-H-2, and 118-H-3 Burial Grounds located in the 100-HR-2 source OU (Figures 2-2 and 2-3).

Signatories to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) developed a coordinated *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)/*Resource Conservation and Recovery Act of 1976* (RCRA) site characterization and remediation strategy to comprehensively and expeditiously address environmental concerns associated with the Hanford Site. This strategy, known as the *Hanford Past-Practice Strategy*, emphasizes integration of the results of ongoing site characterization activities into the decision-making process as soon as practicable (a procedure called the "observational approach") and expedites the remedial action (RA) process by emphasizing the use of interim actions.

Investigation and remediation of the past-practice waste sites is governed by the Tri-Party Agreement, initially signed in 1989 by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology. This agreement grouped the waste sites into 78 OUs, each of which was to be investigated and remediated separately under the CERCLA program or the RCRA program, depending on the designation of the OU.

Like each of Hanford's National Priorities List sites, the 100 Area was divided into OUs, which are groupings of individual sites based primarily on geographic area and common waste sources. Geography also played an important role in the grouping of individual sites into OUs. Because it may be difficult to assess the environmental impacts of one site without obtaining information about other sites in the vicinity, grouping adjacent sites into OUs allows the impacts of the sites to be assessed as a group rather than on an individual basis.

The *Proposed Plan for the 100 Area Burial Grounds Interim Remedial Action* (DOE-RL 2000b) recommends excavation and disposal of the burial ground debris and soils that are above cleanup levels.

These types of burial grounds received a broad spectrum of chemical and radiological wastes. Because of the heterogeneous nature of their contents, these sites have been difficult to characterize, and quantitative characterization data are generally not abundant.

Figure 2-1. The Hanford Site.

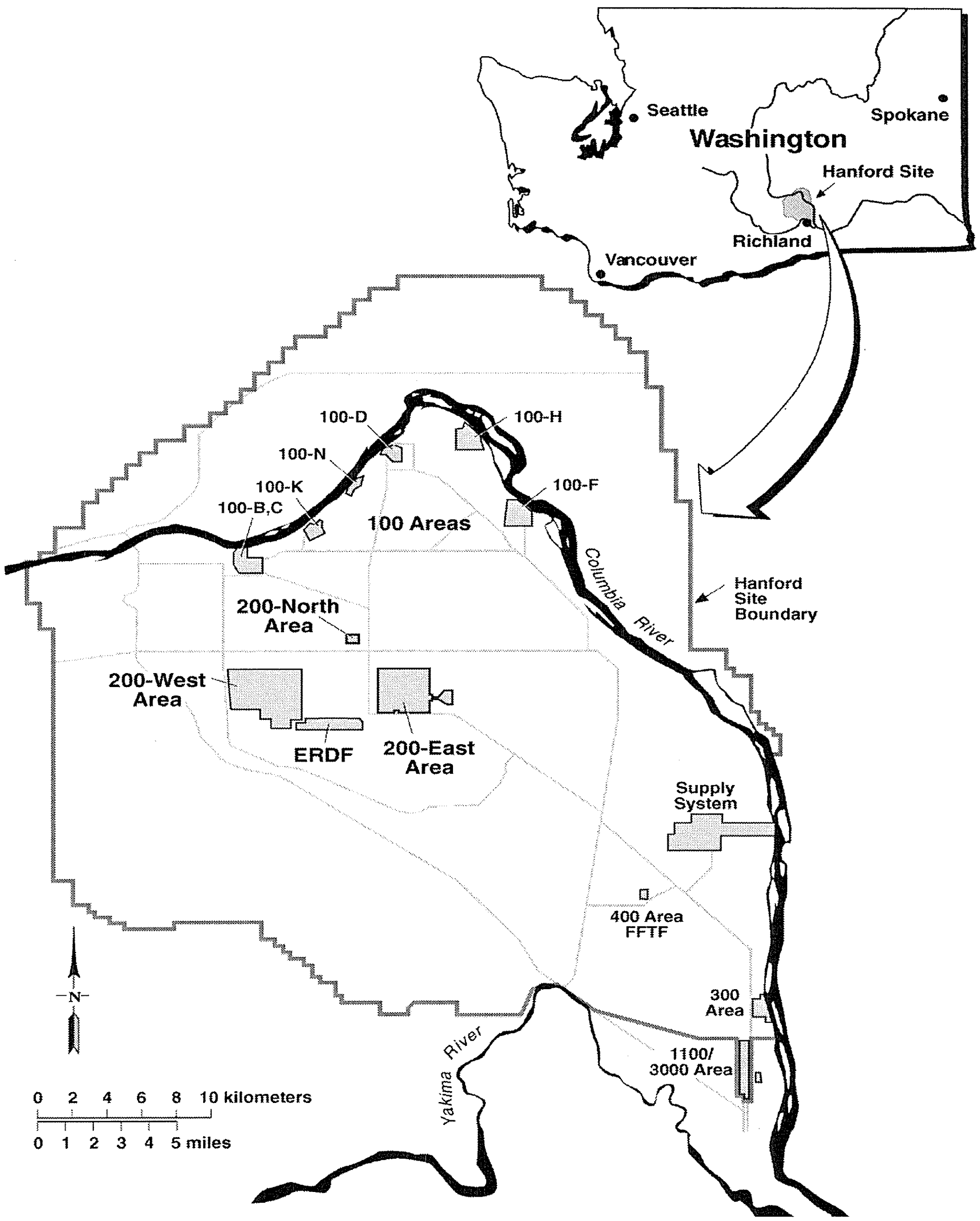


Figure 2-2. 100-DR-2 Operable Unit.

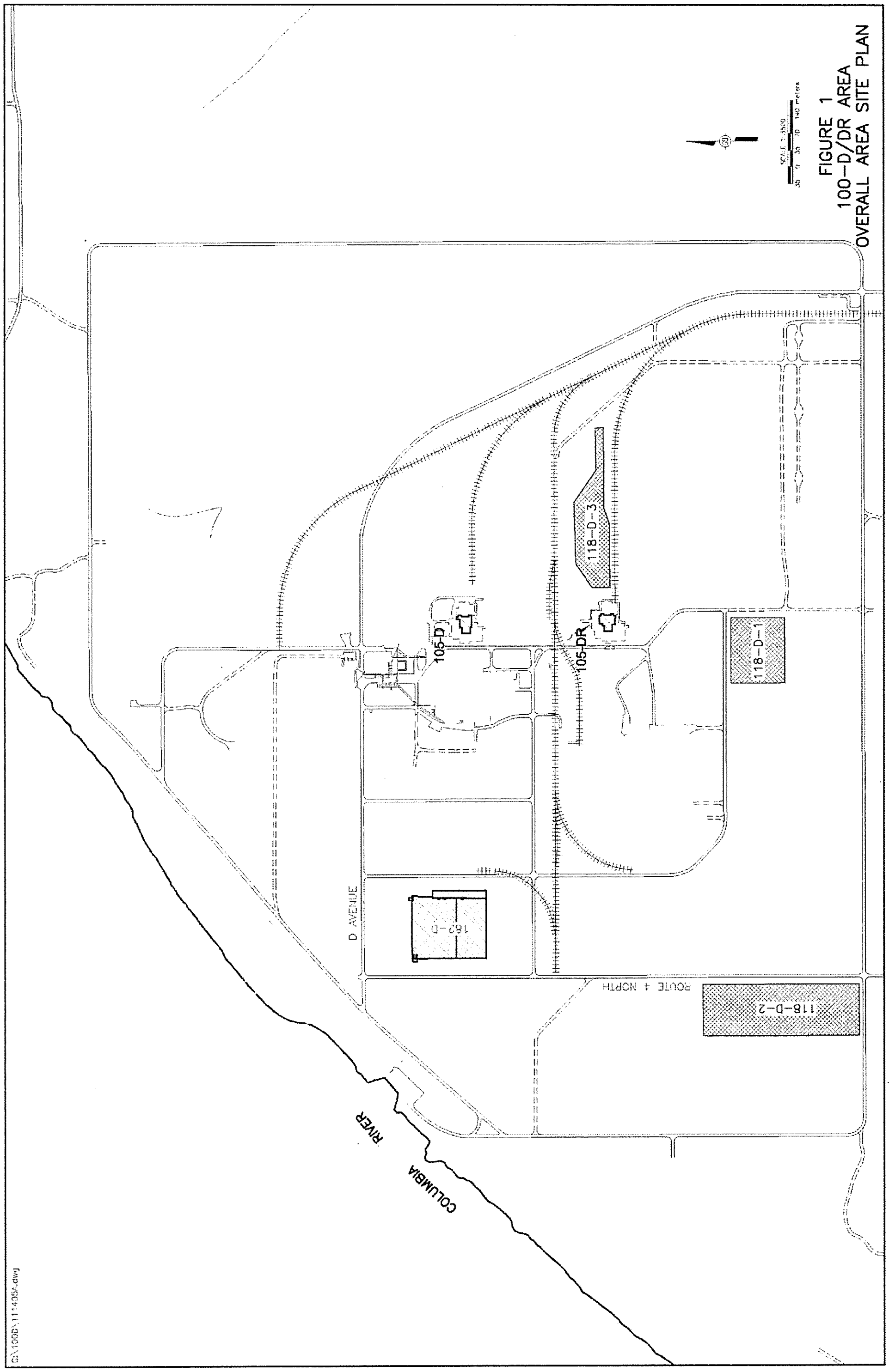
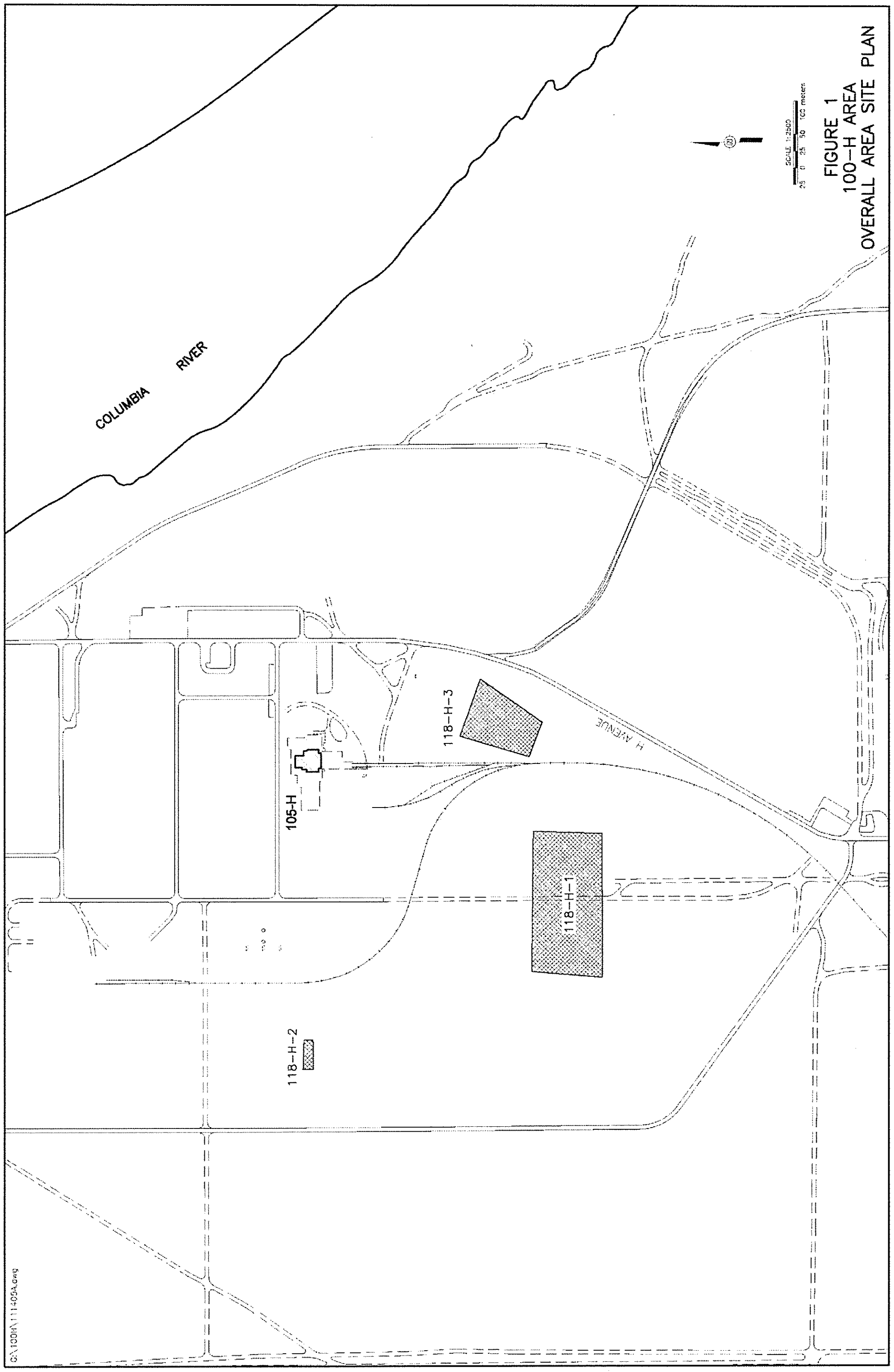


Figure 2-3. 100-HR-2 Operable Unit.



Known attributes of the general content burial grounds include the following:

- None of the general content burial grounds currently appear to be impacting groundwater.
- Waste forms include contaminated trash (soft waste), noncombustible material (e.g., reactor internals), equipment, liquids, SNF oxide, SNF metal, soil, and gases, including compressed gas cylinders and tritium associated with waste.

This FHC addresses the activities (e.g., excavation, sampling, sorting, handling, and stabilization of liquids; characterization, handling, packaging, and disposition of SNF pieces; aboveground interim storage; and surveillance and maintenance of exposed soil and filled containers of waste staged at the burial grounds) that are to be used to achieve remediation goals for the waste site, the inventories that are anticipated for the site, and the hazards associated with these activities and inventories.

Past excavations at the 100 Area burial grounds have unearthed SNF elements, i.e., 118-B-1 and 118-C-1. This calculation conservatively assumes a bounding inventory of 25 spent fuel elements at each waste site. This number is based on the number of "standard" plutonium production elements (25) found during remediation of the 105-F and 105-H Fuel Storage Basins (FSBs).

118-D-1 (100-D Burial Ground Number 1)

The 118-D-1 Burial Ground is an inactive solid waste site that operated from 1944 to 1967. The 137- by 114-m (450- by 375-ft) site was located approximately 274 m (900 ft) south of the 105-DR Building. The burial ground was used to dispose of irradiated reactor parts, dummies, thimbles, rods, gun barrels, and other contaminated solid waste. The burial ground contains several trenches running north and south, but the exact number is unknown. The trenches were 91 by 6 by 6 m (300 by 20 by 20 ft) deep with a 6-m (20–ft) space between them. The unit received an estimated 10,000 m^3 (13,080 yd^3) of waste. The burial ground was divided into four sections to allow grouping of like waste in each section (Hanford Drawing H-1-4046).

118-D-2 (100-D Burial Ground Number 2)

The 118-D-2 Burial Ground is an inactive solid waste site that operated from 1949 to 1970. The 305- by 109- by 6-m (1,000- by 357- by 20-ft)-deep site is located approximately 823 m (2,700 ft) southwest of the 105-DR Building. The burial ground was used for disposal of an estimated 10,000 m^3 (13,080 yd^3) of miscellaneous contaminated solid waste, irradiated dummies, splines, rods, thimbles, and gun barrels. It is divided into four sections to allow grouping of like wastes (Hanford Drawing H-1-4046).

Beginning in April 1966, 100-N Area low-level radioactive solid wastes were also buried at this site. The site contains several trenches running east-west (the exact number is unknown) and five disposal pits. The trenches are 20 m (66 ft) wide at the surface, 6 m (20 ft) wide at the bottom, and 6 m (20 ft) deep. Each trench is composed of two small pits, constructed with railroad ties, with interior dimensions of about 1.8 by 1.8 m (6 by 6 ft), and placed within an excavation 7.3 by 7.3 m (24 by 24 ft) deep. All were covered with 1.8 m (6 ft) of soil. Historical documents report that there was a fire in this burial ground in March 1958 (GE 1958a). The fire was difficult to extinguish and required large volumes of water (several tank truck loads) to put out; therefore, contaminants could potentially have been washed to the soil column beneath this burial ground.

118-D-3 (100-D Burial Ground Number 3)

The 118-D-3 Burial Ground is an inactive solid waste site that operated from 1956 to 1973. This burial ground was located approximately 107 m (350 ft) east of the 105-DR Building. Typically, trenches were 61 by 6 by 6 m (200 by 20 by 20 ft) deep, and the spacing between trenches was not uniform. This burial ground was divided up into five sections to allow grouping of like wastes (Hanford Drawing H-1-4046). It also contained a burning pit that was used for the disposal of low-level radioactive combustible wastes. The burial ground was used for the disposal of miscellaneous contaminated solid wastes and irradiated dummies, splines, rods, thimbles, and gun barrels.

The site was also used for disposal of 100-N solid wastes, extending the eastern boundary. Two additional solid waste burial ground sites in or very near this burial ground are considered a part of it, these being the Minor Construction burial ground number 2 and the "grave." The Minor Construction burial ground number 2 was a trench dug in 1953 to receive contaminated thimbles, rod guides, and miscellaneous waste removed from the 105-DR Reactor during an extended Ball 3X shortage. The contaminated wastes were then covered with 1.8 m (6 ft) of dirt. The "grave" was a small trench dug in March 1954 to receive effluent water from the number one DR west effluent expansion box during repairs. The trench received specific wastes and was covered as soon as the waste was received. It is assumed that the trench was dug very near the expansion box and should be located in the northwest corner of the burial ground.

118-H-1 (100-H Burial Ground Number 1)

118-H-1 is an inactive mixed solid waste burial site that is recognized as having been the primary burial ground for the 100-H Area. It is located approximately 396 m (1,300 ft) southwest of the 105-H Reactor Building. This site operated from 1949 until 1965 and received an estimated 10,000 m^3 (13,080 yd^3) of waste from 100-H Reactor operations. The site received reactor process tubing, dummy fuel elements, contaminated lead brick, and other reactor hardware. The burial ground was enlarged in 1955. The total dimensions were 213 m (700 ft) long by 107 m (350 ft) wide and 61 m (200 ft) deep. The numerous trenches in the east/west-oriented burial ground run north to south. Trench layout details may be seen on Hanford Site Drawing H-1-13484. Cross-sectional details and wooden crib design are provided on Hanford Site Drawing P-3475. The site is primarily backfilled with 1.8 m (6 ft) of soil cover. Near the southwest corner, portions of several horizontal controls rods are buried in slit trenches with 0.6 to 1.2 m (2 to 4 ft) of soil cover. A fire at the site occurred in October 1960 (GE 1960).

118-H-2 (100-H Burial Ground Number 2) (H-1 Loop Burial Ground) (P-13 Pit)

118-H-2 is an inactive, solid mixed waste burial ground located approximately 457 m (1,500 ft) west of the 105-H Reactor Building. The site operated from 1955 to 1965 to receive a small volume of contaminated and activated test material and contaminated pipe. The burial ground was about 43 m (140 ft) long, 15.2 m (50 ft) wide, and 4.6 m (15 ft) deep when excavated in 1955.

Two concrete vaults were placed in the excavation to receive activated and contaminated hardware associated with an experimental reactor test facility, reportedly on behalf of the U.S. Navy. The easternmost vault was used for this purpose in 1955 when a test loop, or "stainless steel double tube" was transferred from the reactor to this vault for burial after several years of irradiation. Additional information on the “P-13” assembly project can be found in the *Reactor Section, Radiation Monitoring Report for Month of March, 1955* (GE 1955) and , *Emergency Removal of the KAPL-120 In-Pile Tube* (GE 1956). The second vault, constructed in 1958 to the west of the first vault, was intended for a similar use but was not used in the program. A small quantity of contaminated pipe was placed in it at the time of reactor deactivation in 1965. Both vaults were filled with gravel and the excavation was backfilled to grade. Additional clean soil has since been added to form a berm that rises approximately 0.9 m (3 ft) above grade over the burial ground.

118-H-3 (Construction Burial Ground)

The 118-H-3 Burial Ground is an inactive solid mixed waste burial ground located approximately 244 m (800 ft) southeast of the 105-H Reactor Building. It operated from 1953 to 1957 and received approximately 3,000 m^3 (3,924 yd^3) of reactor components and hardware, including lengths of contaminated 40.6-cm (16-in.) pipe that were used as chutes for the removal of reactor vertical safety rod thimbles and other components from reactor modification programs. The burial ground is 91 m (300 ft) long, 61 m (200 ft) wide, and 6 m (20 ft) deep. It consists of multiple north/south running trenches that have been backfilled to grade with approximately 1.8 m (6 ft) of soil.

2.1 SITE HISTORY

From 1943 until 1990, the primary mission of the Hanford Site was to produce nuclear materials for the defense of the nation. Waste disposal activities associated with this mission resulted in the creation of more than 1,000 past-practice waste sites. The waste sites are contaminated with radioactive constituents, chemical constituents, or combinations of both.

The U.S. Army Corps of Engineers established the Hanford Site in 1943, as an integral part of the Manhattan Engineering District mission to produce nuclear weapons for use in World War II. The Hanford Site, then referred to as the Hanford Engineer Works, had a specific mission: the production of weapons-grade plutonium to fuel the nation’s nuclear arsenal. This was accomplished through a three-step process that involved the manufacturing of fuels in the

300 Area, irradiation of fuels in the 100 Area reactors, and the extraction and production of plutonium at the chemical separations plants in the 200 Areas.

Direct land burial in excavated trenches, termed "burial grounds," was used to dispose of solid, low-level radioactive materials associated with reactor operations (e.g., equipment and structural debris). Each reactor area (except the 100-N Area) includes burial grounds containing irradiated reactor hardware and other solid waste materials incidental to facility operations, mixed with soil. Each reactor area also has specialty burial grounds, where wastes from reactor alterations or other specific activities (e.g., biological research or facility construction) were disposed.

During the first 30 years of reactor operations, virtually all of the radioactive wastes were buried in the reactor areas where they were generated. However, beginning in 1968, increasing amounts of waste were transported to the centrally located 200 Areas for disposal.

The 100 Area of the Hanford Site were placed on the EPA's National Priorities List on November 3, 1989, under CERCLA. A subset of the Hanford Site waste sites on the National Priorities List also falls under the jurisdiction of RCRA.

2.2 PROJECT DESCRIPTION

The 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground remediation activities described subsequently will remediate the site to meet rural-residential land-use requirements. Additional descriptions of the OU and descriptions of the remediation methodology are presented in background documents for this project (e.g., *100 Area Burial Grounds Focused Feasibility Study* [DOE-RL 2000a], RDR/RAWP [DOE-RL 2005a], and the *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* [DOE-RL 2001]).

The work scope for RA at the waste sites includes the following:

- Perform all necessary activities to remove, treat (if required), and dispose of contaminated soil, liquids, miscellaneous materials, SNF pieces, and piping as specified in *Declaration of the Record of Decision: U.S. DOE Hanford 100 Area; 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (ROD) (EPA 2000).

- Remove and dispose of any below-grade structural material (e.g., spline silos) that interferes with RA.

- Backfill the sites consistent with future use.

- Establish necessary interfaces with existing site services (utilities and support personnel) and the Environmental Restoration Disposal Facility (ERDF).

- Material that requires macroencapsulation to meet ERDF waste acceptance criteria will be treated at the waste site or at ERDF to meet the criteria and then disposed at ERDF.

- Material that does not meet, or cannot be treated to meet, ERDF waste acceptance criteria will be treated/disposed at another facility approved by the EPA and the Washington State Department of Ecology.

RA activities for the burial ground will include the following elements:

- Removal and Transfer of Contaminated Concrete Structures to ERDF. Uncontaminated concrete may be size reduced and disposed at an onsite demolition debris disposal facility or used as a source of backfill.

- Removal and Disposal of Piping. Contaminated piping (e.g., irradiated process tubing) will be size reduced and disposed at ERDF. Uncontaminated piping may be size reduced and disposed onsite at a demolition debris disposal facility.

- Characterization, temporary storage, packaging, and shipment for transfer of suspect SNF pieces if discovered during excavation or sorting activities.

- Removal and Disposal of Contaminated Soil and Debris from Trenches and Silos. The burial grounds consist of several separate trenches and silos that contain contaminated debris and soil. Contaminated soil and debris will be removed to the bottom of the engineered structure (trench or silo). Excavated structural components and debris will be sorted and size reduced as required. After being loaded into containers, contaminated soil, debris, and miscellaneous materials will be transported to and disposed at ERDF.

Other activities that may be required during the course of this project include the following:

- Grout Stabilization, Coating, and/or Packaging/Repackaging for Radioactive Particulate Control and/or Shielding. Grouting may be used to control the spread of radioactive particulates or to provide shielding to protect workers.

- Removal and Storage of Dangerous Wastes. Containers or other materials that may contain, or consist of, dangerous waste will be removed and placed (staged) in an appropriate waste storage location. Sampling and analysis may be required in order to characterize the waste for designation and disposal.

- Sampling and Analysis. Sampling and analysis will be conducted to characterize waste (including any segregated high-radiation dose anomalies), guide remediation, and verify that cleanup goals have been achieved.

- Site Backfilling and Regrading. After structures and debris have been removed, the burial ground will be backfilled, as required, from a designated borrow source and regraded.

- Mercury Treatment. Elemental mercury may be treated onsite by amalgamation or other treatment prior to packaging and shipment for disposal. Any mercury-contaminated soils and other mercury-contaminated materials (e.g., spill cleanup materials) will be treated onsite or offsite, as appropriate.

- Characterization, Handling, Storage, Treatment, and Disposal of Liquids. Liquids will be identified, characterized, and evaluated, as necessary, on a case-by-case basis for storage, treatment, and disposal.

- Piercing (pressure relief) of compressed gas cylinders.

Certain site-specific factors influence the extent of remediation required at the waste sites. These waste sites will require selective excavation and removal of contaminated soil/debris that have concentrations above ROD cleanup requirements.

Soils will be removed from areas identified by sampling and analysis to be contaminated above cleanup limits. Survey results will be used to verify that the excavated material meets the requirements of the ERDF waste profile, which has been established to ensure compliance with that facility's waste acceptance criteria.

Soil or material treatment (e.g., macroencapsulation), if required, may be performed by the remediation subcontractor but will be addressed on a case-by-case basis as a separate work scope. Groundwater remediation is being performed under a different program within DOE. Site revegetation will be performed under a separate subcontract to be awarded after the RA work is complete.

This remediation project supports the future vision for the 100 Area, which includes accelerated RAs that will allow for potential economic development by local city/county governments, and the private sector. The 100 Area source OUs will be remediated to meet rural-residential land-use requirements.

2.3 SEGMENTATION

No segmentation within a burial ground was applied in the determination of the FHC. Each burial ground is treated as an individual facility because the distance between them precludes bringing hazardous material from different facilities together or causing harmful interaction from a common severe phenomenon.

2.4 DEMOGRAPHICS

Population size and distribution are important criteria to assess the magnitude of risk to the public from radiological releases. The cities of Desert Aire, Mattawa, and Othello are the closest populated areas. From the 100-D Area to Desert Air, Mattawa, and Othello, the distances are 30.97, 32.53 and 39.41 km, (19, 20, and 24 mi) respectively. From the 100-H Area to Desert Aire, Mattawa, and Othello, it is 24.75, 26.31 and 35.29 km (15, 16, and 22 mi), respectively.

Approximately 376,000 people lived within a 50-mile radius of the Hanford Meteorological Station (HMS) in 1990. As of 1999, about 17,000 people were employed on DOE-related projects at the Hanford Site.

Recreationists, consisting of hunters, fishermen, boaters, and off-road sports enthusiasts, enjoy activities throughout various parts of the area in proximity to the Hanford Site. The primary fishing season is June through November; the main hunting season is from October through January. The Columbia River, which is adjacent to the 100-DR-2 and 100-HR-2 OUs, is used for recreation and is open to the public. The heaviest use of the area by recreationists is on weekends and holidays, usually in the early morning. On average, 50 fishermen and 10 hunters are present east of the Columbia River during the weekdays. These numbers increase to about 100 fishermen and 50 hunters on weekends and holidays.

2.5 SITE LOCATION

The 100-DR-2 and 100-HR-2 OUs are located on the Hanford Site, which is situated in the southeast portion of Washington State (Figure 2-1). The Hanford Site is located within Grant, Benton, and Franklin Counties. The 100-DR-2 and 100-HR-2 OUs are located on the south bank of the Columbia River, in the 100 Area, which is in the northernmost portion of the Hanford Site. Figures 2-2 and 2-3 show the applicable burials grounds and the surrounding features for the 100-D/DR Area and 100-H Area, respectively.

2.6 POPULATION DISTRIBUTION

Approximately 60 individuals will work on the 118-D-1, 118-D-2, and 118-D-3 Burial Grounds Remediation Project and another 60 on the 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Project. The bounding, unmitigated release that forms the basis for the FHC of the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Projects represents exposure to the maximally-exposed individual 30 m (98 ft) from the release.

2.7 SITE FEATURES

This section contains information on the meteorological and geological characteristics of the area.

2.7.1 Meteorology and Climate

Temperature extremes vary from -29 °C to 46 °C (-20.20 °F to 114.8 °F) on the Hanford Site as reported in the *Hanford Site Climatological Data Summary 2004 With Historical Data* (Hoitink et al. 2005). Climatological data are available from the HMS (which is located between the 200 East and 200 West Areas on the Hanford Site) and from the 300 Area meteorological station. The HMS has collected data since 1945. Appendix A addresses the potential effects associated with exposure to heat/cold extremes.

2.7.2 Precipitation

Precipitation that infiltrates through the ground (i.e., recharge) has the potential to carry contaminants through the soil to the groundwater and the river. Average annual precipitation on the Hanford Site is 16 cm (6 in.). In 1995, the wettest year on record, 31.3 cm (12 in.) of precipitation was measured; in the driest year, 1976, only 7.6 cm (3 in.) was measured. Most precipitation occurs during the winter, with more than half of the annual amount occurring from November through February. Appendices A and B assess the potential effects associated with internal flooding and flooding caused by a probable maximum flood.

January is the wettest month, with an average of nearly 100 hours of precipitation, producing just over 2.3 cm (0.9 in.) of water. Days with greater than 1.3 cm (0.5 in.) of precipitation occur less than 1% of the year (Hoitink et al. 2005). Appendix A evaluates water intrusion during remediation project activities. Topography within the 100 Areas is generally flat, gently sloping toward the Columbia River, with no obvious drainage channels. The flat topography, the lack of well-defined drainages, and the arid to semi-arid climate suggest that little (if any) surface water would accumulate within the site.

Mean annual run-off from the Pasco Basin is approximately 3% of the total precipitation. The remaining precipitation is assumed lost through evapotranspiration, with less than 1% recharging the groundwater system as reported in *Consultation Draft: Site Characterization Plan, Reference Repository Location, Hanford Site, Washington* (DOE 1988). The *Estimated Recharge Rates at the Hanford Site* (Fayer and Walters 1995) estimated recharge at the 100-F Area as high as 55.4 mm/yr (2.2 in./yr) on disturbed, nonvegetated sites with Rupert sands. The presence of shrub-steppe and cheatgrass vegetation reduces infiltration. At a recharge rate of 55.4 mm/yr (2.2 in./yr), precipitation would take about 28 years to travel 7.6 m (25 ft).

2.7.3 Prevailing Winds

Historical meteorological data indicate that the prevailing winds align themselves with the Columbia River, traveling predominantly from the west and west-northwest. The wind speed averages 10 to 12 km/hr (6.2 to 7.4 mi/hr) in winter and 13 to 17 km/hr (8 to 10.5 mi/hr) in summer. The strongest winds are generally southwesterly, with speeds up to 130 km/hr (80.7 mi/hr). More than 90% of the southwesterly winds exceed 30 km/hr (18.6 mi/hr). The daily average wind speed at the 100 Area ranges from 8 to 16 km/hr (5 to 10 mi/hr).

High winds are likely to occur during site remediation activities. In the summer, high-speed winds from the southwest cause most of the dust storms. There is a remote possibility that high winds may also cause airborne missiles (e.g., scrap wood and miscellaneous items at the site). Blowing dust occurs at wind speeds higher than 30 km/hr (18.6 mi/hr) in areas with limited ground cover and low moisture content. An average of eight dust storms per year is recorded at the HMS. A storm generally lasts just over 3 hours; however; durations of 18 hours have been documented. The maximum wind gust recorded at 15 m (49 ft) above ground surface at the HMS was 128 km/hr (79.5 mi/hr) (Hoitink et al. 2005). A peak gust of 138 km/hr (85.7 mi/hr) was calculated with a 100-year return period. The return period for gusts of 113 km/hr (70.2 mi/hr) is 10 years (Stone et al. 1983).

2.7.4 Weather Phenomena

At the Hanford Site, dust storms are a severe weather phenomenon that occur most frequently and have the greatest potential effect.

A severe tornado of the midwestern type is highly unlikely because of the Pacific Northwest's climatologic and topographic conditions. Only two tornado funnel clouds and one small tornado (June 1948) have been observed within the Hanford Site in the 34-year period between 1945 and 1978. On average, Washington State experiences just over one tornado each year. The probability of a tornado striking a point at the Hanford Site is estimated to be 9.6 by 10^{-6} per year. As stated in the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes* (DOE 1987), tornadoes are infrequent and generally small in the northwest portion of the United States.

Washington State has an annual mean number of thunderstorm days of 10, which is considered to be relatively low (IEEE 1991). Thunderstorms occur most frequently from April to September. Lightning strikes in the summer occasionally have ignited range fires in the Hanford Site region.

2.7.5 Hydrologic Description

The 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds are situated within the Columbia River drainage basin. Two major rivers within the Columbia River drainage basin border the Hanford Site: the Columbia and Yakima Rivers.

The following information on groundwater is provided primarily in the context of whether the water table might reach the bottom of the burial grounds and potentially leach contaminants from the buried materials. Groundwater in the unconfined aquifer at the Hanford Site generally flows from recharge areas in the elevated region near the western boundary of the Hanford Site, towards discharge areas along the Columbia River. The approximate distance from the bottom of the burial grounds to the highest recorded groundwater level ranges from 8 to 27 m (26.2 to 88.5 ft).

The release of contaminants to the vadose zone and migration to the aquifer is not a likely scenario at most solid waste burial grounds, because (1) they received mostly irradiated solid wastes that are not subject to leaching, and (2) evapotranspiration rates are so high that little precipitation is available to pass through the burial grounds and carry contaminants to the vadose zone. Based on the sources of contamination and the viable contaminant release/transport mechanisms, the potentially contaminated media are (in order of likelihood of occurrence and predominance of material) hard wastes, soils, soft wastes, air, biota, and groundwater. The maximum floods on record occurred in 1894 and 1948, with peak flows at the Hanford Site estimated at 21,000 m^3/s (27,468 yd^3/s) and 20,000 m^3/s (26,160 yd^3/s), respectively in the *Hanford Site National Environmental Policy Act (NEPA) Characterization* (Neitzel 1997). These floods occurred before the Priest Rapids Dam and several other upriver dams had been constructed.

The flow regulation resulting from the upriver dams significantly lessens the projected intensity of the potential 1,000-year flood to about 12,400 m^3/s (16,219 yd^3/s). The regulated flood of 1997 was just under this level. Thus, a 1,000-year flood would not inundate any of the reactor areas or burial grounds as stated in the *Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan* (DOE 1996b) because of the regulated flows.

Neitzel (1997) also discusses a potential flood caused by a 50% breach of the Grand Coulee Dam, caused by sabotage or war. This breach would cause a flow estimated at 600,000 m^3/s (784,800 yd^3/s) and would cause significant flooding, including (for the Hanford Reach area) the remainder of the 100 Areas, West Lake and Gable Mountain Pond, the 300 Area, and nearly all of Richland, Washington (DOE 1996b). The potential effects from this scenario on waste sites have not been considered further because "...a breach under these conditions would indicate an emergency situation in which there might be other overriding major concerns" (Neitzel 1997).

2.7.6 Geology and Seismology

The Hanford Site lies within the Columbia Intermontane Province, which is bordered on the north and east by the Rocky Mountains, on the west by the Cascade Range, and on the south by the Basin and Range Province. The dominant geological characteristics of the Columbia Intermontane Province have resulted from flood basalt volcanism and deformation processes.

The geologic structure beneath the 100 Area is similar to much of the Hanford Site, which consists of three distinct levels of soil formations. The deepest level is a series of basalt flows that have warped and folded over time. The top level is also a basalt layer, the top of which ranges in elevation from 46 m (150 ft) below sea level, to 64 m (210 ft) below sea level. The middle layer, known as the Ringold Formation, consists of silt, gravel, and sand.

The Hanford Site is Seismic Design Criteria Category C, as defined by the *International Building Code* (IBC 2000). Earthquake records for the Pacific Northwest extend to the 1850s. A network of seismographs was installed on the Columbia Plateau in 1969 (DOE 1989). Slope subsidence is the most likely result of seismic activity at a particular excavated burial ground. Seismic activity and related phenomena are not anticipated to result in significant radiological consequences to workers and the public because of the low energy of anticipated seismic activity and the form and distribution of the hazardous substances. In addition, it is not anticipated that multiple accident events would be initiated (similar to what may occur at a facility) as a result of a seismic event at the burial grounds.

The stratigraphic record in the Pasco Basin suggests that tephra is the only primary product of Cascade Range volcanism that may reach the Pasco Basin during the next 10,000 years. During the May 18, 1980, eruption of Mount St. Helen's, about 7.6 mm (0.3 in.) of ash was deposited at the HMS tower. In the first 9 hours following the eruption, about 1 mm (0.04 in.) of uncompacted ash was recorded at the Energy Northwest Plant 2 meteorological station. The Hanford Site was not in the main path of the ash cloud.

2.7.7 Local Ecology

A species of concern near the 100-H Area is the federally protected bald eagle with restrictions around established roosting sites from November 15 through March 15. Established bald eagle roosting and nesting sites are found near the 100-H and 100-F Areas, but the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds are not within the 800-m (2,625-ft) buffer zone established to protect the eagles.

2.8 ADJACENT FACILITIES

It is unlikely that any accidents specific to facilities outside of the 100-DR-2 or 100-HR-2 OUs (e.g., explosions and spills) will impact the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds MAR due to significant distances between this OU and surrounding facilities. The most probable impacts would be a release of inventory from a nearby facility due to an accident or a fire. No activities are being carried out at the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds that would be adversely impacted if an evacuation were required. A release of inventory from a nearby facility would not interact with the MAR at the remediation sites, resulting in new accident scenarios. A fire resulting from an accident at an adjacent facility is bounded by the high-wind scenario evaluated in Section 4.0. Therefore, based on the above discussion, no significant adverse impacts on the remediation site would occur from other projects within the Hanford Site.

3.0 OPERATIONS

The ROD for the 100 Area OU (EPA 2000) directs DOE to perform remediation activities at selected waste sites located within the OU. These activities include selective excavation of soils contaminated above cleanup levels, as well as excavation of wastes (e.g., drums and debris) from former process waste sites that were primarily used to dispose of liquid and solid waste streams originating from the reactor operations in the 100 Areas.

Work on the 100-D/DR and 100-H Burial Sites will be performed as two separate projects, but the work scope will be performed in the same manner.

The RDR/RAWP governs the implementation of the RA process required by the ROD. The expected activities that will be performed at the burial grounds are fully described in the RDR/RAWP (DOE-RL 2005).

3.1 PROJECT ACTIVITIES

The remediation of the burial grounds is divided into separate subactions/activities: (1) mobilization; (2) project readiness; (3) excavation; (4) waste treatment; (5) volume reduction; (6) required treatment; (7) anomalous waste segregation; (8) characterization; (9) stabilization; (10) material handling and transportation; (11) soil/debris characterization and waste designation; (12) characterization of suspect SNF, temporary storage, packaging, and transportation for transfer of SNF pieces; (13) decontamination; (14) drummed waste characterization; (15) drummed waste stabilization; (16) waste transport, (17) close-out sampling and surveying; and (18) demobilization. Each activity is described in the following subsections. Dust suppression is discussed in Section 3.20. Operational systems are discussed in Section 3.21.

3.2 MOBILIZATION

Mobilization involves the establishment of the infrastructure that is needed to support the conduct of remediation and typically includes the following activities:

- Construction of access or haul roads
- Installation or relocation of electrical utilities (may include diesel- or gasoline-fueled electrical generators)
- Installation of personnel changing/shower/personal protective equipment (PPE), lunchroom, and administrative facilities (typically portable trailers), and weigh station
- Siting of radiological survey tent (possibly including propane heaters and small propane storage tanks), decontamination facility, container transfer area, area of contamination

(AOC) boundary, contaminated material staging pile area (including run-on/run-off control), and clean overburden storage pile areas

- Staging of earthmoving or other heavy equipment (including water trucks) and diesel and gasoline fuel storage tanks/refueling area
- Staging of maintenance equipment, including lubricating oils, hydraulic fluids, flammable material storage area/cabinets, and welding and cutting torch cylinder storage areas
- Establishing radiological/hygiene monitoring areas (air monitors, portal monitors, step-off pads, boundaries, posting)
- Establishing sample storage areas
- Obtaining excavation permit in accordance with Hanford Site procedures

3.3 PROJECT READINESS

WCH procedures will determine the level of project readiness evaluation that will be needed to start operations. The project readiness evaluation, if needed, will determine if project operations can safely be initiated and that all regulatory, work implementing, and subcontractual documentation have been approved.

3.4 EXCAVATION

Equipment required to support the work activities at the burial grounds would be evaluated to ensure that any critical assumptions identified within the FHC are not affected. The initial remedial investigation activities have been completed. Areas with known contamination are excavated to a predetermined depth with the appropriate surveys being conducted.

Field screening will be ongoing throughout the excavation phase. Contaminated materials will be placed into transfer containers for shipment to ERDF or other disposal sites or will be interim stored in the case of some drums. The uncontaminated soils will be stockpiled for site backfill when all of the contaminated materials have been removed. The contaminated debris will be cut or compacted, as necessary, and placed into transfer boxes for shipment to ERDF.

Visible dust emissions from the sites are not permitted. Active excavations shall use water or other methods, as approved, for dust control in accordance with agreements between the DOE, Richland Operations Office, EPA, and the Washington State Department of Health. Water usage for dust control shall be minimized to protect against contaminant migration. Crusting agents or fixants shall be applied to any disturbed portion of the contamination area that will be inactive for more than 24 hours. Material to be disposed at ERDF shall also comply with the moisture content and other applicable requirements of the ERDF waste acceptance criteria.

Materials that do not meet the ERDF waste acceptance criteria will typically be placed in a storage area within the AOC or staging pile area, pending treatment and/or identification of an alternate disposal method or until waivers are granted. Contaminated soils that exceed the ERDF waste acceptance criteria are bounded by the soil inventory identified in Appendix C.

3.5 WASTE TREATMENT

Waste that requires treatment prior to disposal at ERDF will be retained within the approved onsite area or transported to ERDF pending treatment and disposal at ERDF. Waste pending treatment and disposal at ERDF may be held in specified locations at ERDF on a case-by-case basis with regulatory, procedural, and functional approval. Waste that requires a treatment not currently available at ERDF will be treated onsite, transported to Central Waste Complex or shipped offsite for treatment and/or disposal in accordance with regulatory approval.

Soils contaminated with chemicals at levels exceeding waste disposal acceptance criteria would be treated by fixatives/solidification/stabilization or other appropriate treatment technology. Solidification and stabilization are treatment technologies designed to reduce contaminant solubility, mobility, and toxicity through chemical or physical changes. Typical solidification and stabilization agents include cement-based materials, clays, asphalt, and resins (e.g., epoxies). Contaminated soil and/or contaminated products treated to meet applicable treatment standards would be disposed in the same manner as other materials that meet waste acceptance criteria without treatment.

The selected remedy (in accordance with the ROD) is currently to remove, treat (if required), and dispose. For purposes of the design basis, "treatment as required" has two main components: (1) treatment to reduce waste volume, thereby lowering remediation costs, and (2) treatment as a regulatory requirement (e.g., dangerous waste).

3.6 VOLUME REDUCTION

Waste volume reduction practices, such as minimizing cross-contamination during RA or segregation of clean overburden from contaminated materials, will be implemented where feasible.

3.7 REQUIRED TREATMENT

Treatment of soils may be required, based on state dangerous and federal hazardous waste regulations established in *Washington Administrative Code* 173-303-140 and 40 *Code of Federal Regulations* (CFR) 268.

The treatment requirements for dangerous waste will not be developed as a part of remedial design. However, dangerous waste may be encountered. Dangerous waste will be collected in the AOC, staging piles within the onsite area, or stored in containers that meet the substantive requirements of the regulations. Substantive requirements for staging piles are developed on a case-by-case basis, subject to approval by the regulatory authority. Once dangerous waste is confirmed, an appropriate treatment plan will be initiated that considers waste type(s) encountered, anticipated waste volumes, and associated treatment economics.

3.8 ANOMALOUS WASTE

Anomalous waste (i.e., waste that needs to be set aside for characterization and/or treatment) will be set aside in staging piles or containers. Unknown anomalous waste will be characterized more extensively through a combination of field screening or analytical laboratory characterization, using a graded approach as described in the sampling and analysis plan (SAP).

3.9 LIMITED CHARACTERIZATION

Additional field investigation activities may include test pit excavation, field radiological testing, and collection/analysis of samples. Findings from the field investigations will be evaluated and incorporated through a revision of this document or internal office memoranda, as needed.

3.10 STABILIZATION

Some waste materials may require stabilization to maintain worker exposure to airborne contaminants and/or direct radiation as low as reasonably achievable (ALARA). Stabilization methods may include the use of grouts to encapsulate particulates and/or to provide shielding. Other methods of fixing contamination such as coatings or expandable foams may also be considered. Exposed soil surfaces will be stabilized through the application of soil fixatives if the site is to be left unattended for greater than 24 hours or the meteorological forecast includes a high-wind warning (see Section 3.20).

3.11 MATERIAL HANDLING AND TRANSPORTATION

Material-handling and transportation activities will be performed inside the remediation site boundaries. Contaminated materials are loaded into the shipping containers (provided by the ERDF) and moved by haul truck to the survey station. At the survey station, the loaded shipping containers are surveyed to verify that the outside is free of radiological contamination. If clean, the containers are moved to the transfer station where an ERDF haul truck picks up the container. When necessary, decontamination will be conducted in accordance with Section 3.14. Transportation to the disposal facility is provided by ERDF personnel. The project and ERDF personnel ensure that all appropriate shipping requirements, including use of appropriate shipping containers and labeling, are met. Containerized waste may also be temporarily stored at the waste site to accommodate surveying and loading schedules.

Certain bulky items that exceed the capacity of standard ERDF containers (e.g., large metal objects, piping, concrete sections) may be size reduced, packaged, and shipped in accordance with the *Environmental Restoration Disposal Facility Waste Acceptance Criteria* (BHI 2002b) and the *Supplemental Waste Acceptance Criteria for Bulk Shipment to the Environmental Restoration Disposal Facility* (BHI 2005c) with specified criteria and procedures. Shipment of U.S. Department of Transportation hazardous materials will comply with 49 CFR or will require safety documentation demonstrating an equivalent degree of safety.

3.12 SOIL/DEBRIS CHARACTERIZATION AND WASTE DESIGNATION

The extent of radiological contaminants will be monitored onsite using a combination of hand-held and fixed-mounted sodium iodide detectors. Additional alpha, beta, and gamma detectors may be used as determined by the project radiological engineer or the SAP. These detectors will be used to guide excavation in accordance with the observational approach to remediation. The contaminant data will be entered into appropriate databases and used for guiding remedial excavation, packaging the waste, adjusting waste profiles, and providing backup data to support completion of waste tracking forms.

Chemical characterization data will be obtained by discrete samples of soil and debris in accordance with the SAP with analysis provided by a contract laboratory. The laboratory will follow protocols provided in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846* (EPA 1995). Laboratory results will be entered into a database to support RA site closeout decisions and contaminated waste disposal. Chemical field screening methods may be used and will follow methods specified in WCH procedures or other methods specified in the SAP. Details of the characterization requirements are described in the data quality objective summary report/SAP.

3.13 SPENT NUCLEAR FUEL PIECES

During normal remedial activities conducted at the burial ground sites, initial visual screening of waste debris for anomalies will be conducted within the site. The waste debris will be moved to the sorting area for further sorting. Additional visual and radiological sorting will be conducted in the sorting area when spoils are handled to facilitate further inspection of the waste debris for any additional anomalies. Specific procedures for radiological screening for the SNF pieces have been incorporated into burial ground work instructions. The key elements of the sorting process as it relates to SNF are identified in Section 5.0, "Controls and Commitments." The expected radiological monitoring readings from SNF pieces are based upon the sorting processes and potential fuel expected to be found. Any SNF discovered during radiological surveys will be segregated in the sorting area as a high-radiation dose anomaly. The maximum number of fuel elements allowed for storage at any time shall comply with the requirements as specified within Section 5.0, "Controls and Commitments." Placement of high-dose anomalies will then be placed in a shielded location within the sorting area (e.g., a bunker built with concrete ecology blocks).

High-dose rate anomalies that conform to the physical characteristics of SNF are considered suspect SNF. Suspect SNF will be located within the shielded location and managed to the requirements as specified in Section 5.0, "Controls and Commitments." Suspect SNF is then characterized within the sorting area to determine if each suspect anomaly is (confirmed) SNF. Characterization activities can include washing, weighing, measuring, gamma spectroscopy, and other examinations. If the anomaly is determined to be SNF, the type or model of reactor fuel will be determined, if possible.

Any discovered SNF is also managed and controlled in accordance with the requirements of the safeguards and security plan within the sorting area, until the SNF is packaged onsite and transported offsite. Packaging activities can include weighing and other characterization activities and packaging into an appropriate shipping container (e.g., PAS-1 cask).

3.14 DECONTAMINATION

Decontamination will occur at the waste site, the survey station, or a decontamination station. If minor contamination is found on the outside of shipping containers at the survey station, it will be cleaned at the waste site or survey station. If major contamination is found, the container will be routed to the waste site or a decontamination station for cleaning. Following decontamination, the shipping container will then be returned to the survey station to ensure that the outside of the container is free of removable contamination. A decontamination station may also be used to remove contamination from equipment and materials upon completion of RAs. Equipment and materials exiting waste site contamination areas or surface contamination areas may be decontaminated at the waste site.

Rinsate will not be collected when decontamination occurs within the waste site. Any rinsate collected at the decontamination facility washdown pad (primarily expected to be used for decontaminating haul trucks and containers) may be processed for reuse/recycle; used for dust suppression; or sampled, treated, and disposed. Decontamination fluids collected at the washdown pad will initially be pumped to a trailer-mounted tank and held there pending further processing. If the decontamination fluid is found to be above purgewater acceptance criteria levels, the rinsate will be transferred to tanker trucks and transported to the 200 Area Effluent Treatment Facility or will be used as dust suppressant on contaminated sites.

3.15 DRUMMED WASTE CHARACTERIZATION

Drummed waste, particularly radiologically contaminated drummed waste, is not expected to be exhumed from these sites. However, if such waste is found, the drums will be sampled to characterize their contents. The remediation of the burial grounds shall implement the applicable drum handling plan for any drummed waste found in the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds.

3.16 DRUMMED WASTE STABILIZATION

Burial ground remediation will follow the drum handling plan to stabilize any drummed waste, if such waste is found at the site. Field instructions shall discuss fire protection, health and safety requirements, administrative controls, and contingency plans.

Activities to be conducted when stabilizing the drums include the following:

- Initial drum inspection
- Drum relocation and repackaging
- Drum access
- Stabilization
- Stabilized interim storage.

The project may store the excavated drums at other parts of the OU (rather than at the waste site) during remediation. If AOCs are established at other parts of the OU, an evaluation will be made to determine if there are any impacts to this FHC. The same fire protection measures that are in place during drum characterization will be in place during drum stabilization.

3.17 WASTE TRANSPORTATION

The transport of contaminated material requires reusable containers to be filled at the excavation site, surveyed and decontaminated, if required, taken to a storage area, and then hauled to ERDF for unloading. Transportation will be performed in accordance with WCH procedures and subcontract documents.

Based on its ability to satisfy the basic functional criteria, as well as its adaptability to large or small waste sites, the typical ERDF transport container will be used as the design basis for handling contaminated soils and debris. To fulfill their intended purpose, the containers satisfy the following requirements:

- Containers are of steel construction, lined with a minimum 0.15-mm (6-mil)-thick form-fitting removable plastic liner. The liner shall be sized to fit inside the container, to be folded over, and to completely surround the maximum container load.

- Containers are similar to roll-on/roll-off type with open top.

- Container payload is up to 22.7 metric tons (25 short tons)

- Pieces of SNF will be segregated from the low-level wastes and prepared for shipment to the appropriate facility.

3.18 CLOSEOUT SAMPLING AND SURVEYING

Closeout sampling and surveying will be conducted after all contaminated soil and debris has been removed from the burial ground pits and trenches. The purpose of the closeout sampling is to provide a reasonable level of confidence that the RA goals have been met. At a minimum, four composite samples, or as required by the SAP, will be collected and analyzed for each unique set of contaminants of concern depending on the burial grounds specific waste streams and dimensions.

3.19 DEMOBILIZATION

Two methods of demobilization can occur during the remediation of the burial grounds: (1) demobilization from the waste site before closeout (where closeout is defined as the completion of all stabilization activities, such that the site can be unmanned), and (2) final site closeout followed by demobilization of the waste site.

Demobilization from the waste site (before closeout) typically consists of the following activities:

- Excavated materials that have previously been determined to be stable are configured to minimize releases of inventory (e.g., dry overpacked) and are staged onsite. These activities will be ongoing during the remediation process.
- General backfilling and regrading may be performed to prevent surface ponding if precipitation occurs.
- A crusting agent is applied to all soil surfaces and stockpiles to provide dust control during the period of inactivity.

Prior to closeout, the waste site will be evaluated by appropriate site and safety personnel to determine what activities/actions are required to place the site in a condition that meets any controls identified in the authorization basis.

The accident scenarios evaluated in Section 4.7 bound any accidents that might impact the site after it has been demobilized (prior to closeout). Activities involved with demobilization of a waste site after closeout will consist of decontaminating equipment, as well as those activities associated with the removal of fencing and boundary barriers.

3.20 DUST SUPPRESSION

Two methods of dust suppression may be used for the remediation of the burial grounds. The first method is water application. Water is generally applied at the excavation dig face, on haul roads, parking lots, etc., whenever dust can be generated during the project. The second method is the use of crusting agents. A fixative (crusting agent) will be applied to a dig face before periods of inactivity longer than 24 hours when sustained wind speeds over 32.2 km/hr (20 mi/hr) are forecasted for the 100 Area.

The project will receive daily weather forecasts from the HMS, which will provide the predicted sustained wind velocity forecasts. Decisions to apply crusting agents will be based on these forecasts. In addition, the project will be on the call list for weather advisories and will use those reports for decision making.

3.21 OPERATIONAL SYSTEMS

Remediation of the burial grounds will use water to provide dust suppression during remediation activities. The project has two water supply sources: (1) raw river water fill stations in the 100 Area located near the river and (2) potable water fill stations installed at the project.

The potable water supply is not at risk of contamination from the excavation site. Potable water is trucked to the site for sanitary use. Potable water is not used for dust suppression.

The dust suppression water trucks are filled through an air gap between the tank and the fill line. The water line also has a double check valve to prevent any backflow into the raw water system. The water truck may travel down haul roads within radiological buffer areas to spray the roads within the waste sites. Upon exiting the radiological buffer area, the water truck may be surveyed for contamination. The water truck will be surveyed when leaving a radiological buffer area for contamination control but will not be surveyed when leaving a radiological buffer area for dose control.

The project will have at least one water truck onsite to apply water. Water is applied where appropriate, using truck nozzles, sprinkler systems, and fire hoses. Pipes may be used to direct water flow onsite.

Crusting agents will be stored onsite. The agent will be mixed with water in the water trucks before application.

4.0 HAZARD ANALYSIS

MAR calculations for the 100-D burial grounds (WCH 2006b, *Determination of Material at Risk and Hazard Screening for 100-D/DR Burial Grounds and Remaining Sites*) and 100-H Burial Grounds (WCH 2006c, *Determination of Material at Risk and Hazard Screening for 100-H Burial Grounds and Remaining Sites*) were performed that determined the radiological inventory for each burial ground to be *Hazard Category 3*. Because the initial hazard categorizations were determined to be *Hazard Category 3* for each of the sites, the development of an FHC was required. In accordance with WCH procedures, an FHC and supporting hazard analysis must be prepared for any site or project that receives an initial hazard categorization of *Hazard Category 3* or above.

This section consists of the hazard analysis and the FHC for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds. The hazard analysis consists of a hazards identification phase (Section 4.1) and a hazards evaluation phase (Sections 4.2 and 4.3). The *118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation* (WCH 2006a) determined the FHC to be less than hazard Category 3.

4.1 HAZARD IDENTIFICATION

The objective of the hazard identification process is to provide a basis from which to analyze the hazards associated with a facility. To achieve this objective, the hazard identification process must address the following:

- Characteristics of the inventory of hazardous substances in the facility
- Sources of energy inside the facility capable of interacting with those inventories
- Sources of energy outside the facility capable of interacting with those inventories
- Nonroutine hazards unique to the facility.

4.2 RESEARCH

A document search was conducted for documents related to the waste site. The index was reviewed and documents were inspected for pertinent information. Additional searches were conducted in various libraries and records holding areas for construction drawings and photographs for the waste site.

Maps and engineering drawings references identified in the searches described above were reviewed by engineering staff to identify types and quantities of buried items and other potential information sources referenced therein. Pertinent references in these documents were obtained and reviewed as well.

The hazards identified during the hazard identification process (Appendix A, Table A-1) were generated from the above-referenced sources of information. These sources were used to identify the inventories of hazardous substances within the waste sites associated with the remediation of the burial grounds, as well as the types of energy sources that could impact these inventories. Other information sources included process knowledge, interviews with staff, and engineering judgment.

The depth of detail employed during the review of site-related documentation was considered sufficient to allow an adequate characterization of the hazards present at the site. This research also included a review of the following types of information:

- Characterization reports
- Hazard assessments
- Hazard screenings
- Hazard identification documents
- Criticality evaluations
- Expedited response actions
- Previous DOE-approved safety analyses
- Hanford Site Waste Information Data System
- Remedial investigation/feasibility study reports or studies
- Waste characterization reports
- Excavation reports
- Closeout reports.

4.3 INVENTORY

Accurate inventory records listing the types and quantities of waste buried in the 100 Area burial grounds are not abundant. Records were not kept of the amounts or types of radionuclides buried as solid waste in the early days of the Hanford Project. During the 1950s and 1960s, some documents were issued regarding waste disposal activities, but the waste disposal records were not detailed, resulting in uncertainty in current knowledge of burial ground contents. Beginning in the late 1960s, routine reports of radioactive waste disposal in the 100 Area were more complete, including the land area used, the waste volume, the activity of specific radionuclides, and the location coordinates.

The inventory data for the hazardous materials (both chemical and radiological) for the burial grounds are included as part of the hazard identification worksheets (Appendix A) and were taken from the *Estimates of Solid Waste Buried in the 100 Area Burial Grounds* (Miller and Whalen 1987) study and project-specific data obtained from other burial ground experience (e.g., 100-B/C burial grounds).

4.3.1 Qualitative and Quantitative Description of the Waste Materials

Potential radiological contaminants associated with the contaminated soil at these sites are tritium, carbon-14, calcium-41, cobalt-60, nickel-59, nickel-63, strontium-90, silver-108m, barium-133, cesium-137, europium-152, europium-154, and plutonium-239. Tritium and carbon-14 come from broaching and overbore of the channels in the graphite core of the reactor and from disposal of depleted desiccant (silica gel) used to dry the recirculated reactor gases. Cobalt-60 and nickel-63 are present mainly as impurities of aluminum process tubes. Silver-108m is present as an impurity of the lead-cadmium poison pieces. Strontium-90, cesium-137, europium-152, and europium-154 are present as scaling on the aluminum process tubes.

Potential radiological contaminants associated with the SNF pieces at these burial grounds are americium-241, cadmium-113m, cesium-137, europium-152, krypton-85, niobium-94, palladium-107, plutonium-238, plutonium-239, plutonium-240, plutonium-241, selenium-79, samarium-151, strontium-90, technetium-99, uranium-238, and zirconium-93. The radionuclide inventory associated with these sites is presented, in detail, in the MAR calculations (WCH 2006b, 2006c) and Appendix A.

With respect to the nonradioactive hazardous materials inventory, lead, mercury, and cadmium are present as lead-cadmium poison pieces, cadmium sheets, and lead bricks. Mercury is present as elemental mercury from failed instruments such as manometers and mercury switches. A detailed description of the nonradioactive hazardous materials associated with these sites can be found in Appendix A and the MAR calculations (WCH 2006b, 2006c).

4.3.2 Adjustments to Material Inventories

4.3.2.1 Liquids. Conservatively, the entire liquid inventory is considered to be at risk for all hazard scenarios.

4.3.2.2 Contaminated Soil. A fractional amount of the activity from general radioactive waste was qualified as a noncombustible dispersible solid in the form of a powder.

For purposes of soil removal during high winds, "Particle Resuspension: A Review," (Sehmel 1980) provides a bounding depth of 10 mm (0.39 in.) for soil at risk for resuspension by high wind. A typical trench depth is 4,600 mm (179 in.) so a high-wind event would impact 10/4600 or 0.2%. The amount of soil considered to be available for entrainment due to a high-wind event is conservatively assumed to be 10%.

The amount of contaminated soil considered to be available for damage during a fire is conservatively taken to be 100%.

For the deflagration, dumping/spilling, and dropping/impact hazards, only a small fraction of the noncombustible solid inventory would be expected to be involved in the hazard. The fraction of contaminated soil at risk in these hazards is taken to be 1% of the total soil inventory. This percentage is conservative and bounding based on the assumption that a 25-mm (1-in.) deep layer of a single trench is less than 1% of the total volume. A deflagration, dump, spill, drop, or impact event would occur within a much more localized volume or surface area; therefore, the 1% value is bounding and conservative.

4.3.2.3 Uranium Metal Solids. The spent fuel elements are encased in cladding, though 20% of the fuel elements are assumed to be damaged and breached. Experience at other excavation sites has shown that multiple fuel elements have not been unearthed in the same excavator bucket load.

For the fire hazard event, the airborne release fraction (ARF) and RF values should be applied only to oxide created during a fire and not to any un-oxidized metal. As discussed in Section 4.2.1.2 of *Airborne Release Fractions and Respirable Fractions for Nonreactor Facilities* (DOE 2000a), oxidation of uranium under fire conditions does take place. However, not all of the uranium in the spent fuel is expected to oxidize.

The bounding fire at a burial ground from the standpoint of uranium metal oxidation would be a pool fire involving diesel fuel spilled from a piece of large equipment (e.g., excavator) or from a refueling truck. (Note that other scenarios are bounding for the purpose of deriving other values, such as the percentage of waste impacted by a fire.) The scenario would involve a spill of diesel onto the soil surface of the burial ground such that a pool is formed. The pool is then ignited and burns until the fuel is exhausted. Some fraction of the spilled diesel would be absorbed by the soil, which would serve to reduce the amount of fuel available to burn and, consequently, the duration of the fire. The burning rate of diesel is in the range of 13 to 20 cm (5 to 8 in.) of depth per hour (NFPA 1991, "Fire Protection Handbook").

Given (1) the burning rate of diesel, (2) the absorption of some fraction of the spilled diesel by the soil, (3) the burial ground terrain, and (4) the potential volume of a diesel spill (380 to 760 L [100 to 200 gal]), a reasonably conservative maximum duration for a diesel fuel pool fire at a burial ground is estimated to be 30 minutes (i.e., 6.3 to 10.2 cm [2.5 to 4 in.] of pool depth burned). It is expected that the continuous flame region temperature for a diesel fuel pool fire at a burial ground would range from 900 °C to 1100 °C (1652 °F to 2012 °F). This is consistent with the analysis made in the *Final Hazard Categorization for the Remediation of the 118-B-1 and 118-C-1 Solid Waste Burial Grounds* (WCH 2006e).

The "Basis for Interim Operation for Fuel Supply Shutdown Facility" (Benecke 2003) evaluates the oxidation of uranium metal fuel in a storage building fire. An 8-hour fire duration, including 2.5 hours at or above 1000 °C (1832 °F), is used to determine the fraction of the uranium metal oxidized. The evaluation determined that 5% of the uranium metal would be oxidized in such a fire event.

An investigation titled *Oxidation of Uranium in Air at High Temperatures* (GE 1958b) examined the oxidation of small (.25 to .50 in. [0.6 to 1.3 cm] in diameter by .75 to 1 in. [1.9 to 2.54 cm] in length) pieces of metallic uranium at temperatures ranging from 300 °C to 1440 °C (572 °F to 2624 °F). The cylindrical test specimens were prepared by swaging from a Hanford Site reactor fuel element. Oxidation rate equations for uranium metal as a function of the area to weight ratio of the cylindrical specimens were determined. Using an area to weight ratio of 0.08 cm^2/g

(0.012 in^2/g) for a typical uranium metal fuel element (i.e., 260 cm^2/3,200 g [40.3 in^2/112 oz]), oxidation rates of about 15.5 mg U/cm^2-min and 34.3 mg U/cm^2-min are predicted at 995 °C (1823 °F) and 1200 °C (2192 °F) by solving the appropriate oxidation rate equations in (GE 1958b). This would imply that 121 g to 267 g (4.2 oz to 9.3 oz), or 3.8% to 8.3% of the mass of uranium metal in a typical fuel element would be oxidized in 30 minutes.

Section 4.2.1.2.1 of DOE (2000) discusses oxidation at elevated temperatures in a fire. The *Oxidation of Depleted Uranium Penetrators and Aerosol Dispersal at High Temperatures* study (Elder and Tinkle 1980) is cited that involved 13 experiments, performed from 500 °C to 1000 °C (932 °F to 1832 °F) for durations of 2 or 4 hours. The oxidation of the uranium ranged from 6.2% to 22.1% for the 2-hour fires (1.6 % to 5.5% per 30 minutes) and from 21.3% to 30.2% for the 4-hour fires (2.7% to 3.8% per 30 minutes).

Because the burial ground fire is estimated to burn for 30 minutes, a value of 10% is chosen to represent the amount of uranium metal that oxidizes during the fire hazard scenario. This value bounds each of the references cited above.

4.3.2.4 Noncombustible Solids. The noncombustible solids are comprised of metal reactor waste with surface contamination. In general, only those contaminated particles that are loose (i.e., not combined with the surface matrix) on the surface of the noncombustible solids are subject to release. The MAR is therefore reduced.

It is assumed that 90% of the radionuclide inventory associated with the noncombustible solids inventory is activation products within the solid material and 10% is contamination on the surface of the solid material. For the entrainment/high wind and fire hazards, only those portions of the noncombustible solid inventory that are loose are susceptible to the hazard (according to Section 5.1 of DOE [2000], the ARF and RF values for these two hazards are to be applied only to loose surface contamination and not to radionuclides integral to the bulk solid). The fraction of solid noncombustible MAR in these hazards is taken to be 10% (percent of material that is loose contamination) of the total solid noncombustible inventory.

For the deflagration, dumping/spilling, and dropping/impact hazards, only a small fraction of the noncombustible solid inventory is expected to be involved in the hazard. The fraction of solid noncombustible MAR in these hazards is taken to be 1% of the total solid noncombustible inventory. The basis for the 1% value is similar to that explained in the final paragraph (deflagration, dumping/spilling, and dropping/impact hazards) of Section 4.3.2.2.

4.3.2.5 Combustible Solids. A portion of the general radioactive waste is treated as combustible solids. The fraction of combustible solids available for damage during the hazard event of entrainment/high wind is taken to be 10% of the total combustible solid inventory. A 10% material availability for damage was selected as a conservative upper bound based on the fact that combustible solids are generally packaged in boxes, drums, etc., and are, therefore, afforded a certain self-protection against high winds. Additionally, it would be necessary for the material to be exposed to the winds by the excavation process. It is not credible to assume that the excavator would exhume more than 10% of the radioactive inventory at any given time and leave it exposed for entrainment by high winds.

For the fire hazard, only a portion of the combustible solid inventory in the waste site is at risk (it is unlikely that a fire consumes all the unexcavated waste). Nevertheless, the fraction of solid combustible MAR in this hazard is conservatively taken to be 100% of the total solid combustible inventory.

For the deflagration, dumping/spilling, and dropping/impact hazards, only a small fraction of the combustible solid inventory is expected to be involved in the hazard. The fraction of solid combustible MAR in these hazards is taken to be 1% of the total solid combustible inventory. The basis for the 1% value is similar to that explained in the final paragraph (deflagration, dumping/spilling, and dropping/impact hazards) of Section 4.3.2.2.

4.3.2.6 Uranium Oxide. As discussed in Section 4 of Appendix C, "Assumptions," 0.1% of the total uranium fuel inventory is assumed to be uranium oxide. The thin layer of oxide is only present when the cladding has been breached. It is assumed that 100% of this inventory for all accidents is considered available for release.

4.3.2.7 Summary of Adjustments to Material Inventory. The fraction of each waste form subject to damage from a given hazard (determined in the preceding subsections) is summarized in Table 4-1.

Table 4-1. Summary of Adjustments to Material Inventory.

Material Form	Percent of Total Inventory Subject to Hazard				
	Entrainment/ High Wind	Fire	Deflagration	Dumping/ Spilling	Dropping/ Impact
Liquids	100%	100%	100%	100%	100%
Soil	10%	100%	1%	1%	1%
U Metal	20%	10%	20%	5%	5%
Noncombustible	10%	10%	1%	1%	1%
Combustible	10%	100%	1%	1%	1%
U Oxide	100%	100%	100%	100%	100%

4.4 HAZARDS IDENTIFIED

The hazard types that could affect the inventory of hazardous substances associated with the burial grounds are tabulated in Appendix A, Table A-1. The hazard types and inventories, if applicable, were developed from the information gathered during research on the burial grounds. In order to establish a bounding inventory associated with SNF, historical information associated with the remediation of the 105-F and 105-H FSBs and 100-B/C burial grounds was reviewed. The FSBs and experience from past burial grounds would represent a reasonable estimate of SNF elements or pieces that could be encountered at a solid waste disposal site since the FSBs and burial grounds (i.e., SNF has been found at the 118-B-1 and 118-C-1 Burial Grounds) were known to have received SNF. No historical records found to date indicate that SNF pieces were intentionally disposed in the solid waste burial grounds. There was 1 SNF element removed from the 105-D FSB, a total of 17 SNF elements or pieces were removed from the 105-F FSB, and a total of 8 SNF elements or pieces were removed from the 105-H FSB during remediation. Excavation is still ongoing at this time at the 118-B-1 and 118-C-1 waste sites, but a total of three confirmed SNF elements/pieces have been found at 118-B-1 and four confirmed element/pieces have been found at 118-C-1. All of these SNF elements and pieces were identified to be standard fuel. Several other suspect SNF elements/pieces have been found at the 118-B-1 and 118-C-1 sites but have not been characterized yet and, therefore, have not been confirmed as SNF. The bounding inventory assumed for SNF at each burial ground is based upon a maximum of 25 fuel elements (at 3.6 kg [7.9 lb]/element for a total of 90 kg [198.4 lb]) at each site. The 25-fuel element limit was based on standard elements that may be encountered in the burial grounds. To account for the possibility that other types of fuel elements may be encountered (including overbore elements, high burn-up depleted uranium elements and fuel from N Reactor), a *Calculation of Inventory Ratios for Various Fuel Types* (WCH 2006d) was performed to determine the equivalency between the nonstandard fuel elements and the typical fuel elements. This analysis concluded that 4,160 mm (163.8 in.), with corrections for nonstandard elements, could be accumulated, while remaining within the bounds of the hazard analysis.

Based on the condition of the fuel elements found at the 105-F and 105-H FSBs and at the 118-B-1 and 118-C-1 Burial Grounds, it is assumed that 20% of the fuel elements are damaged. This damage is manifested in the form of an oxide layer that equals 0.1% of the total inventory of the elements. The 0.1% oxide fraction is consistent with assumptions used for fuel at the 105-H FSB (BHI 2000) and the 100-B/C Burial Ground FHC (WCH 2006e). The isotopic inventory of the standard elements was shown to be conservative for single-pass reactor elements during the approval process for BHI (2000) as documented by DOE-RL (2000b). The isotopes not included in the inventory (e.g., uranium-235) are negligible contributors to radiological consequences.

In addition to the standard fuel elements, nonstandard fuel elements were also evaluated. The nonstandard fuel element inventory is determined in the *Calculations to Support the 100-B/C Fuel Element/Target White Paper* (BHI 2005b) and the associated *100-B/C Area White Paper for Fuel Elements and Targets* (BHI 2005a).

The potential radiological dose consequences of standard plutonium production elements compared to the nonstandard elements was evaluated in *Potential Presence of Special Fuel Elements in 105-H Fuel Storage Basin* (BHI 2002c). The standard element was determined to bound any airborne release event (i.e., inhalation pathway, food ingestion pathway) because of the significantly larger inventory of plutonium (and americium) in the standard element compared to the nonstandard elements. The standard element was also determined to bound a direct dose event based on the relative cesium-137 content of each type of element and cesium-137 being responsible for about 98% of the direct dose.

From historical documentation, N Reactor waste was disposed in the 118-D-2 and 118-D-3 Burial Grounds. It is judged unlikely that N Reactor SNF would be found in either of these waste sites, but is accounted for in this document.

Each remediation project activity can be related to a set of generic hazards. The following hazard types were identified as being potentially associated with the burial ground remediation activities:

- Radiological material
- Fissionable material
- Toxic material (heavy metals)
- Carcinogens
- Biohazards
- Corrosive material
- Explosive material
- Reactive material
- Electrical hazards
- Potential/kinetic energy hazards
- Noise hazards
- Temperature extremes
- Asphyxiates
- Seismic
- Exposure to hazardous chemicals
- External exposure to ionizing radiation
- Internal uptake of radioactive material
- Explosive concentration of gases
- Fire/flammable materials
- Natural phenomena hazards.

A number of industrial hazards are associated with the remediation of any waste site. Many of these hazards are common to the nonnuclear industry, and their prevention and/or mitigation consists of standard industrial safety practices. The controls that will be used to manage these routine hazards are discussed in Section 5.3.

4.4.1 Hazards Summary

Following the hazards identification process, generic internal events and project activity-related events that could introduce energy sources to hazardous materials at risk (and thus result in a release of hazardous materials to the environment) were evaluated and documented in Appendix B, Table B-1. The hazard evaluation process for the burial grounds is presented in Section 4.5.

4.5 HAZARD EVALUATION

A hazard evaluation workshop was held. A multidisciplinary team of DOE and contractor personnel completed a systematic review of the potential hazards associated with the remediation activities.

The objectives of this process are as follows:

- Identify the events that could lead to releases of hazardous substances and which require additional quantitative analysis
- Rank these events based on potential consequences and frequency
- Identify engineered mitigative and preventative features that serve to control the hazard
- Identify the commitments and administrative controls necessary to manage the hazard.

This section evaluates the potential interactions of the hazards identified in Appendix A and the project activities described in Section 3.1 that could result in potential consequences to workers or the environment.

4.5.1 Hazard Evaluation Summary

The hazards evaluated in this section originated from the hazard identification process discussed in Appendix A. To this end, the hazard evaluation process involved a facilitated meeting with the following types of personnel:

- Experienced safety analysts
- Radiation control
- Design engineering personnel
- Field engineers
- DOE safety basis specialists.

The hazard evaluation considered a broad range of events. Many of these events have minor consequences (consequence of IV or III-3) and are adequately managed with the programmatic controls identified in Section 5.3. These events do not require detailed treatment in the FHC. Also, although certain events considered in the evaluation process have significant consequences, the probability of some of the events actually occurring is improbable (i.e., any event with a frequency of 1 x 10^{-6}/yr or less). These events also do not require detailed treatment in the FHC.

The results of the hazard evaluation are presented in Appendix B, Table B-1. These hazards were identified as having the greatest potential consequences (i.e., greatest impact to the MAR at the burial grounds remediation sites). The bounding hazards were identified as requiring detailed hazard analysis. Events that were identified as requiring a detailed hazard evaluation are discussed in Section 4.7.

4.5.2 Applicable Activities, Exposures, and Controls

This section presents detailed hazard evaluations for the hazards that were identified in Appendix B, Table B-1, as being the bounding unmitigated release. This section also identifies any activities that would be bounded by the consequences of these bounding accident scenarios and identifies the controls that are applicable to the bounding accident scenarios. These controls are categorized as follows:

- **Special controls.** These controls are required to maintain the assumptions used to determine the FHC.

- **Project-specific controls.** These controls are established to protect the workers for the specific accident under consideration and arise from the hazard evaluation process (e.g., emergency response instructions and material-handling restrictions).

- **Programmatic controls.** These controls are institutional controls established for worker protection that apply to the activity under consideration (e.g., elements of the radiation control program, rigging procedures, and training requirements).

Appendix B identifies several hazardous events that could lead to releases from the burial ground remediation activities (e.g., natural phenomena, impact from excavation equipment). Such events could lead to releases as a result of high winds, dumping materials, wind entrainment from exposed materials, release of oxide from spent fuel elements, and initiation of a fire causing heating of contaminated materials. The following subsections discuss the impacts of these release mechanisms on the materials from the remediation activities, and assess the respirable ARFs.

Modified ARFs were used to adjust DOE -STD-1027 Category 3 TQs for each of the following accident scenarios by multiplying tabled TQ values in DOE-STD-1027 by the ARF value used to determine the original tabled TQ value, and dividing by the ARF appropriate for the specified accident scenario (Appendix C).

One accident scenario is a result of a natural phenomena hazard not initiated by burial ground remediation activities.

During burial ground remediation activities, sections of the waste sites that have not yet undergone remediation will typically have protective soil overburdens to restrict releases of inventory. Dust mitigation measures (dust suppression) are used. The soil that is to be processed during remediation of the burial grounds may also require application of dust suppression prior to placement in containers before shipment to ERDF. These containers use protective tarps to limit the amount of contaminated soil that could be released to the environment.

4.6 CONTROLS

Controls required for any of the following hazard scenarios are identified in Section 5.0. Special controls required for maintaining critical assumptions identified are discussed in Section 5.1. Project-specific controls necessary to manage the hazard scenarios related to the burial ground remediation specific controls are discussed in Section 5.2. Programmatic controls are discussed in Section 5.3.

4.7 BOUNDING ACCIDENT SCENARIOS AND CONSEQUENCES

4.7.1 Dumping

Contaminated Soil: The respirable ARF for soil dumping used in Attachment 4 of the *Memorandum for Distribution, Hazard Categorization of EM Inactive Waste Sites as Less Than Hazard Categorization* 3 (Roberson 2002) is 1.0E-06. The RF value for contaminated soil is 1; therefore, the R value used for dumping of contaminated soil is 1.0E-06.

Contaminated, Combustible Solids: Contaminated combustible solids may be lifted out of a trench and dropped. These combustible materials are typically lightweight. Consequently, they would generate little force during impact with surfaces. Section 5.2.3.1 of DOE (2000) states that no significant suspension of surface contamination is postulated for such materials. Dumping of contaminated combustible solids is not considered further in this evaluation.

Contaminated, Noncombustible Solids: Contaminated, noncombustible solids may be lifted out of a trench and dropped, or digging equipment may impact them. Section 5.3.3 of DOE (2000) addresses free-fall spill and impaction stress to such solids. The bounding ARF for shock vibration of contaminated noncombustible materials that do not undergo brittle fracture is 1.0E-03. The respirable fraction is assumed to be 1.0; therefore, the R value used for this scenario is 1.0E-03.

Contaminated Liquid: The potential exists for containers of liquid to be found in the burial grounds. It is possible that such containers could be spilled during remediation activities. The amount of liquid is expected to be a small fraction of the total volume of the burial trenches. Section 3.2.3.2 of DOE (2000) indicates a spill of aqueous solutions, subjected to a 3-m (9.8-ft) fall distance, has a bounding R value of 1.0E-04.

Spent Fuel Elements: Dumping of spent fuel elements could cause an airborne release of surface oxide. No release from metallic portion of spent fuel elements would occur. It is assumed that the release of oxide is similar to that of contaminated, noncombustible solids. Therefore, the R value for release of oxide due to dumping is 1.0E-03.

4.7.2 High Wind/Entrainment

The soil entrainment rate used in Attachment 4 of Roberson (2002) is 4.0E-03 g/m^2-h.

118-D-3 Contaminated Soil: Assuming a density of 2.27 g/cm^3 or 2.27E+06 g/BCM for the contaminated soil at the 118-D-3 Burial Ground and a soil volume of 80,744 BCM (WCH 2006b), the total mass of contaminated soil at the 118-D-3 Burial Ground is 1.83E+11 g. Of the six burial ground sites discussed in this document, the 118-H-1 site has the largest surface area of the six sites and is equal to 27,738 m^2 (33,174 yd^2). This site will be conservatively used for the surface area to maximize the rate of entrainment, but the 118-D-3 inventory will be used. Assuming that the entire surface area of the trenches is exposed to wind, the rate of entrainment of contaminated soil would be as follows:

$$\chi = 27{,}738 \text{ m}^2 \times 0.004 \text{ g/m}^2\text{-h} = 111 \text{ g/h}$$

Over 24 hours, this translates to 2,660 g (93 oz) of soil entrained. Therefore, the respirable ARF for a 24-hour period would be as follows:

$$R = ARF \times RF = 2660 \text{ g} / 1.83E{+}11 \text{ g} = 1.5E{-}08$$

Contaminated, Combustible Solids: Contamination present on combustible solids would not be readily entrained by the wind because the material was deposited several decades ago and the contaminants are expected to be absorbed onto the materials. It is expected that the amount of contamination released by this mechanism would be less than the amount released through a fire. Therefore, the R value for entrainment is 5E-04.

Contaminated, Noncombustible Solids: Contamination present on noncombustible solids would not be readily entrained by the wind because the material was deposited several decades ago. It is expected that the amount of contamination released by this mechanism would be less than the amount released through dumping. Therefore, the R value for entrainment is 1E-03.

Contaminated Liquid: Containerized liquid would be protected from entrainment by wind. If liquid is spilled, a small pool of liquid could form on the soil surface. Section 3.2.4.5 of DOE (2000) indicates that the bounding R value for entrainment from an outdoor pool at high wind speeds is 4E-6/hr, or 3.2E-05 for an 8-hour duration. (Note: An 8-hour exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3 [DOE 2000b].) Therefore, the R value for entrainment of contaminated liquid is 3.2E-05.

Spent Fuel Elements: No significant airborne release from spent fuel elements (metal) would occur due to high wind/entrainment, which is consistent with Section 4.2.4 of DOE (2000). This scenario is not considered further in this calculation. The airborne release of nonadherent uranium oxide from the surface of a spent fuel element via high wind/entrainment is expected to be less than that released by a drop/impact event. Therefore, the R value for entrainment of the oxide is 1E-03.

4.7.3 Deflagration

Contaminated Soil: The soil at the burial grounds is noncombustible. A fire burning across either site could entrain some of the soil in the updraft, but it would be expected that the amount released by this mechanism would be bounded by the amount of soil released through entrainment. Therefore, the R value is 1.5E-08.

Spent Fuel Elements (Oxide): The spent fuel element MAR during deflagration in the burial ground is limited to the pre-existent oxide. No significant airborne release from uranium metals is postulated, which is consistent with Section 4.2.2 of DOE (2000). The material release is conservatively evaluated as a venting of a pressurized powder at low pressures, consistent with the analysis performed in the *Final Hazard Classification and Auditable Safety Analysis for the 105-H Facility Interim Safe Storage Project* (BHI 2004) and the 100-B/C burial grounds (WCH 2006e). Only low pressures would be produced by this event due to the lack of confinement for the deflagration in an exposed excavation. The bounding ARF in Section 5.3.2.3 of DOE (2000) is 0.005, with a respirable fraction of 0.4 for low-pressure powders being vented. This yields a bounding R value of 2.0E-03.

Contaminated Combustible Solids: Contaminated combustible solids (e.g., soft waste, used PPE) are expected to be present. Such materials are expected to have minimal contamination and do not provide a rigid surface for pressurized gases to act upon. DOE (2000), Section 5.2.2.3, states that the bounding R value for this scenario is 1.0E-03.

Contaminated Noncombustible Solids: Contaminated noncombustible solids are expected to be present. Only those contaminated particles that are loose (i.e., not combined with the surface matrix) on the surface of the noncombustible solids would be subject to release. Section 5.3.2.3 of DOE (2000) indicates that the bounding R value for the release of pressurized gases over contaminated, noncombustible materials is 2.0E-03.

Contaminated Liquid: The potential exists for containers of liquid to be unearthed during excavation activities. It is possible that a deflagration could occur during characterization activities. However, because the amount of flammable gases will be relatively small, the potential damage is anticipated to be low. Section 3.2.2.3.2 of DOE (2000) indicates that the bounding R value for a low-pressure deflagration venting of any solution would be 4.0E-05.

4.7.4 Dropping/Impact

Contaminated Soil: A vehicle or excavator impact to contaminated soil could result in resuspension of the material. However, only a small fraction of the potentially contaminated soil volume could be affected. Section 4.4.3.3.2 of DOE (2000) is not directly applicable to this scenario due to the physical differences between the experimental conditions (powder placed on a plywood sheet or in a quart can within a vented metal box) and the burial ground remediation activities (tens-of-thousands of kilograms of soil), but it does provide a reference point. The bounding R value in Section 4.4.3.3.2 of DOE (2000) is 2.0E-03. The outer areas of the large soil mass will shield the majority of the soil from impact stress, resulting in a bounding R value much less than dumping of contaminated soils (1.0E-06).

Contaminated Combustible Solids: Contaminated combustible solids may be lifted out of a trench and dropped. These combustible materials are typically lightweight. Consequently, they would generate little force during impact with surfaces. Section 5.3.3.2.2 of DOE (2000) states that solids that experience predominantly plastic deformation (e.g. metal, plastics) as opposed to brittle fracture, respond to vibration and shock of the substrate by flexing. Materials adhering to the surface are ejected by the movement depending on how the contaminant is attached to the surface. The bounding R value discussed in Section 5.3.3.2.2 of DOE (2000) is 1E-03, therefore, this will conservatively be used for this scenario.

Contaminated Noncombustible Solids: Contaminated noncombustible solids may be lifted out of a trench and dropped, or digging equipment may impact them. Section 5.3.3 of DOE (2000) addresses free-fall spill and impaction stress to such solids. The bounding ARF for shock vibration of contaminated noncombustible materials that do not undergo brittle fracture is 1.0E-03. The respirable fraction is assumed to be 1.0; therefore, the R value used for this scenario is 1.0E-03.

Contaminated Liquid: The potential exists for containers of liquid to be unearthed during excavation activities. It is possible that an impact to a container could occur during excavation activities. However, the amount of liquid would be expected to be a small fraction of the total volume of the burial trenches. The bounding R value for this scenario would be less than that for a free-fall spill of aqueous solution. Therefore, the R value is 1.0E-04.

Spent Fuel Elements: No significant airborne release from solid uranium metal would result from dropping of spent fuel elements, which is consistent with Section 4.2.3 of DOE (2000). Release of any oxide, however, would be similar to that from a contaminated, noncombustible solid. Therefore, the R value used for this scenario for oxide is 1.0E-03.

4.7.5 Fire

Contaminated Soil: The soil at the burial grounds is noncombustible. A fire burning across either site could entrain some of the soil in the updraft, but it would be expected that the amount released by this mechanism would be less than the amount of soil released through entrainment. Therefore, the R value is 1.5E-08.

Contaminated Combustible Solids: This scenario would involve the ignition of soft waste by an external source such as a range fire or an internal source such as a vehicle fire. Contaminants remaining on soft waste would be well adhered after 30 to 60 years in the burial ground. Also, the soft waste is dispersed in a noncombustible (i.e., soil, metallic components) matrix and would be present as compact piles. Therefore, the R value used for this scenario is 5.0E-04 as reported in Section 5.2.1.1 of DOE (2000) for packaged waste.

<u>Contaminated Noncombustible Solids</u> (including pre-existing oxide on spent fuel elements): A fire could suspend some of the surface contamination due to heating of the metallic components. DOE (2000), Section 5.1 assesses the release of a sparse population of particles attached to the surface of a noncombustible solid. The R value for this scenario is 6.0E-05.

<u>Contaminated Liquid</u>: A potential initiator of an onsite fire could be ignition of gasoline or diesel from the excavator. It is possible for containers to be heated by a fire and, as a result, the liquid contents could also be heated. Section 3.1 of DOE-HDBK-3010-94 (DOE 2000a) indicates that the bounding values for boiling of aqueous solutions are an ARF of 2E-03 and an RF of 1.0, resulting in an R value of 2E-3.

<u>Spent Fuel Elements (Oxide)</u>: This scenario is addressed under contaminated, noncombustible solids.

<u>Spent Fuel Elements (Metal)</u>: Section 4.1 of DOE-HDBK-3010-94 (DOE 2000a) provides ARF and RF values for the oxidation of uranium metal at high temperatures (>500 °C [>932 °F]). The median ARF is 1E-4 and the RF is 1.0, resulting in a R value of 1.0E-4. These parameters are to be applied only to the oxide created during the fire and not to any un-oxidized portion of the uranium metal. The uranium that remains in metallic form is not at risk for release by thermal stress.

4.8 NUCLEAR CRITICALITY

This section documents the results of the nuclear criticality safety evaluation prepared for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Solid Waste Burial Grounds. The evaluations are documented in *Remediation of 118-D-1, 118-D-2 and 118-D-3 Burial Grounds* (WCH 2006g) and *Remediation of 118-H-1, 118-H-2 and 118-H-3 Burial Grounds* (WCH 2006h). It was concluded in WCH (2006g) and WCH (2006h) that non-fuel fissionable waste forms pose no criticality concern. *Hanford Fuel Types in WCH Burial Grounds* (WCH 2006f) addresses SNF and targets. Discovery of SNF elements or pieces occurred during the excavation and sorting operations at these sites, even though historical records did not indicate any evidence that SNF was disposed in the solid waste burial grounds. During remediation activities, SNF has been found and recovered at several facilities within the 100 Areas. The following lists the quantities of elements found to date at the time of this document issuance for the 118-B-1 and 118-C-1 Burial Grounds and other sites in the 100 Area.

- 118-B-1 Burial Ground - three confirmed elements/pieces (two intact and one fragment) and five suspect/uncharacterized elements/pieces

- 118-C-1 Burial Ground - four confirmed pieces and nine suspect/uncharacterized elements/pieces

- 105-D FSB - one complete fuel element

- 105-F FSB - 17 elements/pieces (14 intact and 3 damaged pieces)

- 105-H FSB - eight elements (all intact).

All of the characterized/confirmed elements/pieces found to date have been standard plutonium production fuel elements (enriched [up to 0.947 weight % uranium-235] or natural). Based upon statistical data from *105-H Fuel Storage Basin (FSB) Fuel Element/Target Recovery* (BHI 2002a), approximately 96% of all the fuel elements that were run through the 105-H Reactor were standard fuel elements. An additional evaluation (BHI 2005a), similar to BHI (2002a), was completed and assessed the types of SNF and targets that were used in the 105-B and 105-C Reactors and had the potential to be found during remediation of the 118-B-1 and 118-C-1 Burial Ground waste sites. A 28-cm (11-in.)-long, 3.8-cm (1.5-in.)-diameter uranium enriched (0.947 weight %) fuel element was found to be used in the 105-B and 105-C Reactors and not mentioned in the FHC document. Also, two types of overbore elements were used at the 105-C Reactor. The larger (and also bounding) of the two types of overbore elements was approximately 6 cm (2.4 in.) diameter, made of 0.80 weight % uranium-235, and approximately 22.6 cm (8.9 in.) long. The fuel geometry was a rod in tube design. These two types of fuels are addressed in criticality evaluations for the sites (WCH 2006f). It is assumed that the fuel types run through the 105-B and 105-C Reactors bound those used at the 105-D, 105-DR, and 105-H Reactors and, hence, could have been disposed at the burial grounds.

The evaluation in WCH (2006f) assesses the types of SNF that possibly may be encountered during remediation activities and establishes a conservative limit on the total length of fuel that can be accumulated. The conservative length limit in the criticality safety evaluation [1,080 mm (425 in.)] is based on optimum conditions, which are not credible in any Hanford Site burial ground. If the length limit is not exceeded, there are no normal or credible abnormal conditions that could result in criticality in burial grounds. Administrative controls include the WCH criticality safety and emergency management programs.

As suspected fuel elements or targets (including broken pieces considered by their fractional length) are discovered in the burial grounds, the element/piece lengths and types will be tracked in accordance with special controls and project-specific controls discussed in Sections 5.1 and 5.2, respectively. Sections 5.1 and 5.2 establish the controls necessary for the burial grounds spent fuel inventory.

4.9 FINAL HAZARD CATEGORIZATION

The hazards evaluated in this calculation are identified in Section 4.2. The FHC calculations are summarized below. See Appendix C for calculation details.

Only radionuclides were used in determining the FHC since there are no other hazardous materials that exceed the 29 CFR 1910 or 40 CFR 68 TQs; therefore, analysis of chemical constituents was not included in the FHC calculation. The hazard Category 3 TQs in DOE (1997) are based on the release values (RV) calculated in the *Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation and Liability Act: Radionuclides* (EPA 1989). Release values are determined for each of four exposure pathways: food ingestion, water ingestion, inhalation, and direct exposure. The TQ for a given isotope is 20 times the most restrictive RV. The TQ can be expressed as:

$$Q = 20 \text{ x MIN } \{ RV_{FOOD}, RV_{WATER}, RV_{INH}, RV_{DIR} \}$$

The EPA methodology uses the following assumptions:

1. The RV for the water ingestion pathway assumes that 100% of the material is released to drinking water (see EPA 1989, Appendix B.1).

2. The RV for the inhalation pathway and the RV for the food ingestion pathway both are inversely proportional to a respirable ARF (see EPA 1989, Appendix A.2 and Appendix C.1).

3. The RV for direct exposure for isotopes other than noble gases assumes a point source.

The DOE Office of Nuclear and Facility Safety Policy Nuclear Safety Technical Position (DOE 2002) allows that the hazard Category 3 TQs for radionuclides for which the food pathway and the inhalation pathway are limiting may be revised if, based on the physical and chemical form and available dispersive energy sources for the facility and its hazardous materials, the credible release fractions (ARFs) can be shown to be significantly different from the values used in the EPA Technical Background Document. All potential accident scenarios must be considered under unmitigated conditions. All pathways must be considered and the most limiting pathway must be used.

Based on the guidance in DOE (2002), the revised Category 3 TQ for an isotope in a particular material form can be expressed as:

$$TQ_{Revised} = 20 \text{ x MIN } \{ f_1 \text{ x } RV_{FOOD}, f_2 \text{ x } RV_{WATER}, f_1 \text{ x } RV_{INH}, f_3 \text{ x } RV_{DIR} \}$$

Where:

f_1 is the ratio of the respirable ARF used in the EPA analysis (from EPA 1989, Exhibit A-1) to the largest respirable ARF from any potential accident

RV_{FOOD} is the release value for the food pathway from EPA (1989), Appendix E

f_2 is the ratio of the fraction of material released to drinking water in the EPA analysis (i.e., 1) to the largest fraction of material released to drinking water in any potential accident scenario

RV_{WATER} is the release value for the water pathway from EPA (1989), Appendix E

RV_{INH}	is the release value for the inhalation pathway from EPA (1989), Appendix E
f_3	is the ratio of the dose rate from a point source at 30 m (98.4 ft) to the dose rate from a distributed source of equal activity at 30 m (98.4 ft)
RV_{DIR}	is the release value for the direct exposure pathway from EPA (1989), Appendix E

The potential accident scenarios and corresponding RFs are identified from a hazard analysis. This FHC will be based on the hazard analysis in Roberson (2002) and the scenario analyses presented in Roberson (2002). These analyses form the basis for identifying appropriate respirable ARFs. The RFs will be from DOE (2000), Roberson (2002), or other analyses previously approved by DOE. Equation 2 will be used to generate revised TQs for each constituent present at the burial ground.

The FHC is conducted as follows: the adjusted inventory of radionuclides for each material form and accident scenario is divided by the set of Category 3 revised TQs for that form and accident scenario to get a Category 3 TQ ratio for each isotope. These Category 3 TQ ratios are summed over all isotopes to get a sum-of-ratios value for each combination of facility, material form, and accident scenario.

Because a given accident can impact more than one material form, the sum-of-ratios are then summed across the material forms for each accident scenario. If the Category 3 sum-of-ratios for every accident scenario for a given facility is below 1, the FHC is determined to be below Category 3 for that facility. (The occurrence of two or more accident scenarios at once is judged to be highly unlikely and is not considered in this document.) If the Category 3 sum-of-ratios value for any accident scenario for a given facility is greater than 1, then the Category 3 revised TQ has been exceeded and a revised Category 2 determination must be made.

Using the revised TQ values as described above, the final sum-of-the-ratios for the bounding burial ground (i.e., the 118-D-3 Burial Ground) is shown below in Table 4-2. Since the total sum of the ratios value for all of the waste forms for each accident scenario is below 1, the FHC for all of the burial grounds is below Category 3.

Table 4-2. Maximum Sum-of-the-Ratios.

Waste Form	Dumping	Entrainment	Deflagration	Dropping / Impact	Fire
Soil	3.46E-04	3.43E-03	3.43E-04	3.46E-04	3.43E-02
Liquid	4.65E-03	3.14E-03	3.32E-03	4.65E-03	5.01E-02
Combustibles	Insignificant	6.79E-03	1.29E-03	1.29E-03	6.79E-02
Noncombustibles	2.06E-02	2.06E-01	1.96E-03	2.06E-02	2.51E-02
Spent Fuel Elements (Oxide)	2.18E-02	2.18E-02	4.36E-02	2.18E-02	1.39E-03
Spent Fuel Elements (Metal)	Insignificant	Insignificant	Insignificant	Insignificant	2.26E-01
Sum	**4.74E-02**	**2.41E-01**	**5.05E-02**	**4.87E-02**	**4.05E-01**

5.0 CONTROLS AND COMMITMENTS

5.1 SPECIAL CONTROLS

Special controls are derived from the assumptions made in the FHC that are required to ensure that the FHC remains valid. These controls will be incorporated into the appropriate work implementing instructions developed for the project. Therefore, the special controls for burial grounds are as follows:

- The waste forms encountered at these sites are limited to contaminated soil, miscellaneous contaminated combustible solids, noncombustible solids, liquids, SNF oxide, SNF metal, and gases, including compressed gas cylinders and tritium associated with waste.

- As shown in WCH (2006d), the bounding length of fuel for 25 elements was calculated to be 416 cm (163.8 in.). The discovery of more than the equivalent of 416 cm (163.8 in.) of SNF (with diameter of approximately 3.8 cm [1.5 in.]), at any of the 118-D-1, 118-D-2, 118-D-3, 118-H-2 or 118-H-3 solid waste burial grounds (including broken pieces considered by their fractional length) will require shutdown of remediation operations at the affected location. The bounding fuel length determination considered Single Pass Reactor fuel elements/targets with diameters of up to 3.8 cm (1.5 in.), including high burn-up depleted uranium fuel elements. If fuel is found with a diameter larger than 3.8 cm (1.5 in.) (i.e., N Reactor fuel or Overbore fuel), then WCH (2006d) provides conversion factors for these element types: 2.54 cm (1 in.) of N Reactor outer fuel would equal 25.4 cm (10 in.) of fuel, 2.54 cm (1 in.) of N Reactor inner fuel would equal 11.9 cm (4.7 in.), and 2.54 cm (1 in.) of Overbore fuel would equal 6.6 cm (2.6 in.) of fuel analyzed in this document. Pieces of SNF of indeterminate type or diameter will be assumed to be a piece of N Reactor outer fuel element and the appropriate correction factor (10X) will be applied.

- Operations may resume at the affected site once the inventory of exposed SNF elements is reduced to below the equivalent of 416 cm (163.8 in.) by shipment of the SNF to an offsite SNF staging or storage facility (e.g., FSB at 100-K). Alternatively, SNF may be shipped offsite to maintain the running inventory below the equivalent of 416 cm (163.8 in.) without shutdown of operations. In either case, the DOE Project Manager and Facility Representative shall be notified of the date and quantity shipped, but no further evaluation by DOE is required (DOE-RL 2006a).

If any of the following conditions is encountered, the situation will be treated as a discovery under the FHC evaluation process as described in Sections 1.4 or 5.3.5:

- Waste forms found that are different than those as identified above
- Inventories for each waste form that are determined to be more than what was assumed.

5.2 PROJECT-SPECIFIC CONTROLS

Project-specific controls are established for the protection of workers that apply specifically to the activity under consideration. These controls are derived from the hazard evaluation and engineering judgment. These controls will be flowed down into the appropriate work implementing instructions developed for the project. Based on the hazard evaluation, the following project-specific controls have been identified:

- Provision of fire protection features for drum staging areas (e.g., separation, berms/dikes) as determined under the fire protection program
- Addition of appropriate stabilization materials (e.g., oil, sand, grout) to drums/containers
- Use of intrinsically safe or nonsparking materials when opening sealed drums/containers
- Use of dust suppressants/fixatives as appropriate
- As stated in WCH (2006f), "There are no normal or credible abnormal conditions with fuel types used in Hanford production reactors that could result in criticality at WCH Burial Grounds if the critically safe total length of 425 inches for all fuel elements and suspected pieces is not exceeded." As discussed above in Section 5.1, the bounding length of fuel for accident analysis was calculated to be 416 cm (163.8 in.). Therefore, the bounding fuel length for the accident analysis always bounds the critically safe length limit of 1079.5 cm (425 in.) of SNF, and fuel length will not have to be tracked for criticality purposes.

5.3 PROGRAMMATIC CONTROLS

5.3.1 Conduct of Operations

Conduct of operations is imposed to ensure that work is performed in a controlled and organized manner, that all facets of work activities have been considered, and that necessary documentation is maintained.

The *Remedial Action Conduct of Operations Matrix* (BHI 2005d) presents a graded approach to DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*. The performance of field activities and soil remediation is governed by the *Remedial Action Project Manager's Implementing Instructions* (PMII) (BHI 2005e), applicable field support instructions, and specific work instructions. The PMII is based on a graded approach to the conduct of operations authorized by DOE Order 5480.19. The PMII are applicable to all WCH personnel, assigned or matrixed, who perform activities under the responsibility and direction of the RA Project Manager. The applicability matrix is issued and maintained by the RA Project Manager and identifies elements of the DOE order that apply to project activities, the implementing documents, and any deviations or exceptions to the DOE orders and guidelines.

Conduct of operations strongly emphasizes technical competency, workplace discipline, and personal accountability to ensure a high level of performance during all activities. Project personnel must fully comply with the PMII. If conflict arises with other instructions or directions, work shall be safely stopped until resolution is achieved. Safety is the first priority, and all planning shall include appropriate safety analyses to identify potential safety and health risks and the methods to appropriately mitigate these risks. Workers will not start work until approved safety procedures, instructions, and directions are provided for nonroutine operations.

Conduct of operations requires workers to be alert and aware of conditions affecting the job site. Operators and workers conducting field activities should be notified of changes in the work area status, abnormalities, and difficulties encountered in performing project operations. Similarly, operators and workers shall notify the chain of command of any unexpected situations.
In accordance with the severity of a finding (i.e., emergency condition), notification requirements will be expanded to include upper tier management and regulatory agencies.

5.3.2 Radiological Protection

The radiological controls and protection program is defined in DOE-approved programs and WCH-approved procedures. This program implements River Corridor Closure Contract policy to maintain radiological exposures to levels that are ALARA and to ensure adequate protection of workers. The WCH Radiological Protection Program meets the requirements of 10 CFR 835. Appropriate dosimetry, radiological work permits, PPE, ALARA planning, periodic surveys, and Radiological Control (RadCon) technical support will be provided.

Standard WCH controls for work in radiological areas are assessed as being adequate to control RA project activities. These controls support the planning that identifies the specific conditions and govern the specific requirements for an activity, periodic radiation and contamination surveys of the work area, radiological material handling, and periodic or continuous observation of the work by RadCon. The ALARA planning process will identify shielding requirements, contamination control requirements (including local ventilation controls), radiation monitoring requirements, and other RadCon requirements for the individual tasks conducted during the course of remediation of the burial grounds.

Measures are also taken to minimize the possibility of releases to the environment. Near-field air monitoring and commitments with the Washington State Department of Health will address the radionuclide inventory and activities that could cause potential release of this inventory, but not to the exclusion of 10 CFR 835 requirements.

5.3.3 Occupational Health and Safety Controls

Remediation activities will be controlled by the site-specific health and safety plan, as required by established WCH/River Corridor Closure Project procedures. A site-specific health and safety plan will be written for the remediation of the burial grounds to address the health and safety hazards of each phase of site operation and will include the requirements of a site health and safety plan for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120.

Before work begins, a pre-job briefing is held with the affected workers. This briefing will include reviews of the hazards that may be encountered and the associated requirements. Throughout an activity, daily briefings may also be held, as well as special briefings before major evolutions.

Operations during the remediation of the burial grounds that involve potentially significant nonradiological hazards include the following:

- Asbestos cleanup
- Hot work
- Lead cleanup
- Cleanup of polychlorinated biphenyls
- Biological (insect bites and snakes)
- Temperature extremes
- Working in close proximity to moving equipment
- Possible exposure to organic and inorganic chemicals
- Uneven working surfaces
- Excavation
- Noise.

5.3.4 Training Requirements and Qualifications

The experience and capabilities of the operating staff are extremely important in maintaining worker and environmental safety. Burial grounds remediation requires the employment of workers dedicated to the project for the duration of the radiological efforts. Day-to-day knowledge of ongoing operations, month-to-month understanding of conditions encountered, and ongoing understanding of lessons learned is vital to continued safe operation.

Training requirements will ensure that personnel have been instructed in the technologies to work safely in and around radiological areas and to maintain their individual radiation exposure and the radiation exposures of others ALARA. Standardized core courses and training material will be presented, and site-specific information and technologies will be added to adequately train workers.

RadCon technicians must complete and be current in qualification training. Nonradiological control technician radiological workers must meet the training (i.e., General Employee Radiological Training, RadWorker I, RadWorker II) requirements stipulated in applicable RadCon procedures; this is based on areas to be entered and the types of activities performed.

These training courses require the successful completion of examinations to demonstrate understanding of theoretical and classroom material.

Safety of crane operations is enhanced by operator training (only trained and qualified operators that meet the subcontractor's safety plan and training requirements are allowed to operate the cranes) and periodic maintenance and inspection of the cranes in accordance with the site safety plan and procedures.

Specialized training will be provided, as needed, to instruct workers in the use of nonstandard equipment, in the performance of abnormal operations, and in the hazards of specific activities. Specialized training may be provided by on-the-job training activities, by classroom instruction and testing, or by pre-job briefings. The depth of training in any discipline will be commensurate with the degree of hazard involved and the knowledge required for task performance.

Some site remediation project activities will require the acquisition of expert services, as opposed to project staff training. The assaying of waste packages by specialized methods are examples of activities requiring expert assistance.

The WCH training program provides workers with the knowledge and skills necessary to safely execute assigned duties. A graded approach is used to ensure that workers receive a level of training commensurate with their responsibilities that complies with applicable requirements.

5.3.5 Configuration Control

Established configuration/change control processes ensure that proposed changes are reviewed in relation to the specified commitments. Discovered conditions will be evaluated under the FHC evaluation process so that stabilization and/or recovery actions may be identified and implemented, as appropriate. WCH off-normal event procedures describe the reporting process and protocol applicable to such a discovery.

5.3.6 Quality Assurance

The WCH Quality Assurance Program Plan consolidates the quality program requirements of the WCH prime contract and applicable regulation and DOE orders. It also describes how the quality program requirements are implemented through a system of manuals and procedures. The Quality Assurance Program Plan has been reviewed and approved by DOE as meeting the requirements of 10 CFR 830.120.

5.3.7 Fire Protection

The WCH Fire Protection Program complies with the appropriate requirements of applicable CFR and National Fire Protection Association criteria, as well as the additional requirements of DOE Headquarters and the Richland Operations Office directives included in the WCH contract. The WCH Fire Protection Program was developed to the guidance of the *DOE Fire Protection Handbook* (DOE 1996a). The fire protection implementing procedures are grouped into the following major areas: management and administration, fire protection design, fire protection systems, fire prevention procedures, and special hazard protection procedures.

Each major area contains individual implementing procedures that address the full range of hazards and controls in accordance with the appropriate guidance of DOE (1996a).

5.3.8 Emergency Management

The WCH Emergency Management Program (including preparedness, planning, and response) contains the administrative responsibilities for compliance with the *Hanford Emergency Management Plan* (DOE-RL 1999). The program contains emergency action plans for WCH-managed projects. An emergency action plan will be developed to include the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds and will be part of Vol. 2 when developed. The emergency response actions within the emergency action plan will be provided to recognize incidents and/or abnormal conditions, initiate initial protective actions, and make the proper notifications. The emergency action plan will be consistent with Hanford Site emergency procedures and will meet the requirements of DOE-RL (1999), applicable DOE orders, and state and federal regulations.

All emergency planning and preparedness activities will be consistent with planning and preparedness actions undertaken by other Hanford Site contractors and similar projects. Activities will be in a manner that ensures the health and safety of workers and the public and the protection of the environment in the event of an abnormal incident or emergency at the burial grounds.

Project response to any emergencies (project or neighboring project incident) will be to evacuate personnel to a safe location and initiate the required responsibilities of the Building Emergency Director and other project personnel in support of the Incident Command System.

The WCH Emergency Management Program is based on a graded approach and is commensurate with the hazards and consequences associated with the projects/facilities and activities managed by WCH (involving radioactive and nonradioactive hazardous materials) and/or neighboring facilities.

5.3.9 Access Control

Because of the nature of activities conducted at the burial grounds, various administrative controls will be implemented to ensure public health and safety. Personnel who have unescorted access to the burial grounds remediation site must meet special training requirements (i.e., 24-Hour Hazardous Worker Training, Radiological Worker II Training, pre-job briefing, and required site and activity-specific reading). These training requirements provide adequate assurance of worker safety.

6.0 REFERENCES

10 CFR 830, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

40 CFR 68, "Chemical Accident Prevention Provisions," *Code of Federal Regulations*, as amended.

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APPENDIX A

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, AND 118-H-3 BURIAL GROUNDS REMEDIATION PROJECT HAZARD IDENTIFICATION TABLE

APPENDIX A

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H2, AND 118-H-3 BURIAL GROUNDS REMEDIATION PROJECT HAZARD IDENTIFICATION TABLE

Table A-1 has six columns; the column headings and content are described as follows:

- **Column 1 – Hazard Type:** This column identifies the following types of hazards investigated: radiological (including radioactive material and direct radiation), fissile material, toxic hazards, carcinogenic hazards, biohazards, asphyxiates, flammable/combustible material, reactive material, explosive material, electrical energy, thermal energy, kinetic energy, noise, seismic, and high wind and water intrusion.

- **Column 2 – Location:** This column identifies the location where these activities are to be performed.

- **Column 3 – Form:** This column specifies the form of the hazard type. This column is not intended to provide a detailed identification of the chemical (e.g., oxide) or physical form of the hazard type (e.g., crystalline). Such detail is not considered at the hazard identification stage of a safety analysis.

- **Column 4 – Quantity:** This column quantifies the hazard. Measured values are presented when relevant and available.

- **Column 5 – Remarks:** This column presents information that provides a better understanding of the hazard type, location, form, and quantity.

- **Column 6 – References:** This column lists the information sources used to identify the location, form, and quantity of a given hazard type.

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity: Bounding inventory for each site — Isotope	Total Excluding SNF Inventory (Ci)	SNF Inventory (Ci)	Remarks	References
Radiological	All burial ground sites[a]	Contaminated dispersible material, including broach dust, desiccant, soil, and soft waste.[b] Miscellaneous contaminated nondispersible debris, including aluminum tubes and tube film, aluminum spacers, irradiated lead-cadmium pieces, lead, splines, 25 metallic fuel elements, oxide, and miscellaneous wastes.[c]	Ag-108m	2.56E-02		Assumptions: • 3.6 kg assumed mass per fuel element, 25 fuel elements, for a total of 90 kg (198 lb) of fuel. • 20% of the elements are assumed to be damaged, of which 0.1% is oxidized and available for release.	0100D-CA-N0050 (WCH 2006a) and 0100H-CA-N0027 (WCH 2006b)
			Am-241	1.02E+00	2.96E+00		
			Ba-133	2.66E-02			
			C-14	1.01E+00			
			Cd-113m		3.87E-03		
			Ca-41	7.00E-03			
			Co-60	2.00E-01			
			Cs-137	1.33E+02	1.26E+02		
			Eu-152	1.80E-01	5.33E-04		
			Eu-154	1.27E-01			
			Eu-155	1.33E-01			
			H-3	1.93E+02			
			Kr-85	4.77E+00	2.74E+00		
			Nb-94	3.21E-02	4.00E-03		
			Ni-59	6.14E+00			
			Ni-63	2.29E+01			
			Pd-107		1.00E-04		
			Pu-238	5.22E-02	8.54E-02		
			Pu-239	6.32E-02	6.00E+00		
			Pu-240		1.50E+00		
			Pu-241		1.95E+01		
			Se-79	5.59E-01	1.00E-03		
			Sm-151		1.71E+00		
			Sr-90	1.41E+00	1.24E+02		
			Tc-99	9.99E-02	5.00E+00		
			U-235	7.51E-02			
			U-238	7.66E-02	3.00E-02		
			Zr-93		1.00E-02		

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity			Remarks	References
Fissionable material	All burial ground sites	Contaminated debris mixed with soil, including aluminum tubes and tube film, aluminum spacers, irradiated lead-cadmium pieces, lead, splines, fuel elements or pieces, and soft waste.[b]	**Bounding burial ground**			The criticality screening and evaluation identifies specific controls associated with handling and storage of standard fuel (controls are also established for other types of fuels not expected to be encountered) if found during the remediation of these six sites.	1. 0100D-CA-N0050 (WCH 2006a) and 0100H-CA-N0027 (WCH 2006b) 2. Criticality Evaluations 0100D-CE-N0008 and 0100H-CE-N0003 and 0000X-CA-N0011 (WCH 2006c)
			Isotope	**Nonfuel (Ci)**	**Fuel (Ci)**		
			Am-241	1.02E+00	2.96E+00		
			Pu-238	5.22E-02	8.54E-02		
			Pu-239	6.32E-02	6.00E+00		
			Pu-240	--	1.50E+00		
			Pu-241	--	1.95E+01		
			U-235	7.51E-02	--		
			U-238	7.66E-02	3.00E--02		
Toxic material	All burial ground sites	Contaminated soil and solid wastes (e.g., boron, cadmium, mercury from thermometers, manometers), lead sheets, bricks, and lead wool.	**Contaminant**	**List of all chemicals contaminants in bounding burial ground (kg)**		The mass values were converted to kilograms from the tons values that are presented in Miller and Wahlen (1987). The nonradiological inventory sum of fractions are above unity for 40 CFR 302.4, Table 302.4 RQs. The TQs listed in 29 CFR 1910.119, Appendix A and 40 CFR 68.130, Tables 1 through 4 do not have TQs for the nonradiological substances found in the burial grounds, therefore would increases in the quantities listed would not affect the categorization.	1. 40 CFR 355 2. 0100D-CA-N0050 (WCH 2006a) and 0100H-CA-N0027 (WCH 2006b)
			Cadmium	8.54E+03			
			Lead	3.01E+05			
			Mercury	2.25E+04			
			Arsenic	8.43E+02			
			Chromium	3.48E+03			
			Barium	2.73E+04			
			Selenium	2.57E+02			
			Silver	5.13E+01			
			TPH	4.05E+03			

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity		Remarks	References
			Carcinogen	**List of all chemicals contaminants in bounding burial ground (kg)**		
Carcinogens	All burial ground sites	Cadmium, lead, and potentially other (undocumented) contaminants in soil and as various forms of solid waste.	Cadmium	8.54E+03	The mass values reported were converted to kilograms from the "tons" values that are presented in the cited reference. Cadmium and cadmium compounds are "known to be human carcinogens." Lead in the acetate or phosphate forms is "reasonably anticipated to be a human carcinogen" The nonradiological inventory sum of fractions are above unity for 40 CFR 302.4, Table 302.4 RQs. The TQs listed in 29 CFR 1910.119, Appendix A and 40 CFR 68.130, Tables 1 through 4 do not have TQs for the nonradiological substances found in the burial grounds.	0100D-CA-N0050 (WCH 2006a) and 0100H-CA-0027 (WCH 2006b)
			Lead	3.01E+05		
			Mercury	2.25E+04		
			Arsenic	8.43E+02		
			Chromium	3.48E+03		
			Barium	2.73E+04		
			Selenium	2.57E+02		
			Silver	5.13E+01		
			TPH	4.05E+03		

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Biohazards	All burial ground sites	Insect/rodent bites and excrement.	Undefined quantities.	These hazards are routinely encountered in industry.	Information based on past experience on remediation of burial grounds (e.g., 100-B/C)
Asphyxiates	All burial ground sites	Heavier-than-air gases.	Quantities of such materials will be kept to the minimum needed to support the project. The following are estimated/representative quantities are not meant to be bounding quantities: Acetylene 45 kg (100 lb) Propane 400 L (106 gal)	The potential for the collection of asphyxiate gases to dangerous concentrations is not credible because of the size of the waste site. Activities will be carried out in outdoor, well-ventilated areas.	Information based on past experience on remediation of burial grounds (e.g., 100-B/C)
Flammable material	All burial ground sites	Range fire or onsite fire.	Minimal quantities of vegetation and combustible materials. Radiation area remedial action activities will include steps taken to ensure that most of the site remains vegetation free before and during remediation. Limited quantities of sagebrush and grasses.	A range fire would not cause a significant release of hazardous substances due to the lack of combustibles, especially vegetation that is necessary to propagate a fire within the remediation site.	--
	All burial ground sites	Miscellaneous combustibles, including plastic, masking tape, paper, clothing, and used rags. Pyrophoric material.	Soft waste is conservatively assumed to make up more than 75% of the waste volume in the trenches but contain a small percentage (5%) of the total radionuclide inventory.		Miller and Wahlen, 1987, WHC-EP-0087, Section 4.10, Tables A.1, B.1, B.2, and 11

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
	All burial ground sites	Fuels and oils.	Quantities of such materials will be kept to the minimum needed to support the project. The following are estimated/representative quantities are not meant to be bounding quantities: Flammables Gasoline - 190 L (50 gal) Diesel – 7,600 L (2,000 gal Lubricating Oil - 570 : (150 gal) Lubricating Grease - 360 kg (800 lb) Paints, solvents, adhesives, cleaners, etc. – 380 L (100 gal) Antifreeze - 450 L (120 gal) Brake Fluid - 19 L (5 gal) Hydraulic/transmission fluid - 760 L (200 gal) Compressed Gases Acetylene - 45 kg (100 lb) Oxygen - 45 kg (100 lb) Propane - 400 L (106 gal)	Fuels and oils are found in vehicles brought onsite as part of the remediation activities. These materials will not be stored close to the site.	Information based on past experience on remediation of burial grounds (e.g., 100-B/C)
Corrosive material	All burial ground sites	Various residual liquids and solids waste items.	Records do not indicate that specific liquid wastes were disposed of at this site.	Some liquids have been found in minimal quantities at other similar burial grounds.	1. Miller and Wahlen, 1987, WCH-EP-0087, Section 4.10, Tables A.1, B.1, B.2, and 11 2. Information based on past experience on remediation of burial grounds (e.g., 100-B/C)

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Explosive material	All burial ground sites	Canisters and pressurized bottles of oxy-acetylene, propane, oxygen, and gasoline in equipment fuel tanks and in other approved storage containers.	Quantities of such materials will be kept to the minimum needed to support the project. The following are estimated/representative quantities: Gasoline - 190 L (50 gal) Diesel – 7,600 L (2,000 gal) Paints, solvents, adhesives, cleaners, etc. - 380 L (100 gal) Acetylene - 45 kg (100 lb) Oxygen - 45 kg (100 lb) Propane - 400 L (106 gal)	None.	Information based on past experience on remediation of burial grounds (e.g., 100-B/C)
	All burial ground sites	Aluminum pieces, spacers, splines, and tubes.	Mass of debris will range between different sites and estimated on the order of 1E+04 and 1E+05 kg.	Incompatible with strong oxidizers and acids, halogenated hydrocarbons. Ignition may occur if powders are mixed with halogens, carbon disulfide, or methyl chloride.	Miller and Wahlen, 1987, WHC-EP-0087, Table 11 0100D-CA-N0050 (WCH 2006a) and 0100H-CA-N0027 (WCH 2006b)
Reactive	All burial ground sites	Lead/cadmium pieces, spacers, and shielding.	Cadmium: 8.54E+03 Lead: 3.01E+05 Mercury: 2.25E+04 Arsenic: 8.43E+02 Chromium: 3.48E+03 Barium: 2.73E+04 Selenium: 2.57E+02 Silver: 5.13E+01 TPH: 4.05E+03	Incompatible with strong oxidizers; elemental sulfur, selenium, and tellurium. Incompatible with strong oxidizers, hydrogen peroxide, and acids.	1. Miller and Wahlen, 1987, WHC-EP-0087, Table 11 2. Based on 300-FF-1 and 100-NR-1 designs and experience 3. 0100D-CA-N0050 (WCH 2006a) and 0100H-CA-N0027 (WCH 2006b)

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Electrical	All burial ground sites	Primarily supply lines outside of the excavation fence for office trailers and analytical needs. Some waste sites have high-voltage lines that need to be taken into consideration prior to initiating work activities.	Temporary low-voltage generators, portable welders, and/or light plants may be used within or adjacent to the site. High-voltage power lines may need to deactivated or rerouted.	N/A	--
Kinetic energy	All burial ground sites	Pressurized gas bottles (e.g., oxy-acetylene).	Such materials will be kept to the minimum needed to support the project (see explosive material).	These hazards are routinely encountered in industry. A pressurized missile could strike a patch of contaminated soil, resulting in a release of material. Heavy machinery could collide with the tanks causing a catastrophic failure/ explosion of tank and potential struck by hazard, as well as "puff" release of contaminated soil.	Information based on past experience on remediation of burial grounds (e.g., 100-B/C)
Kinetic and potential energy	All burial ground sites	Spilling loads of soil/falling equipment, dropped "Ecology Block," or machinery, vehicle impacting the contaminated soil, combustible and noncombustible solids including fuel elements during remediation activities.	Project estimates are not meant to be bounding quantities: bucket volume of 6.5 m^3 (8.5 yd^3) of soil.	A falling load could cause a puff-type release of readily breathable contaminated soils to be suspended in air or could collide with contaminated combustibles or noncombustibles.	Based on information from the site technical representative for 100-B/C project

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Kinetic and potential energy (cont.)	All burial ground sites	Aircraft impact.	N/A	The Hanford Site is subject to very limited aircraft traffic due to relative location of airports and normal air traffic patterns.	DOE-RL, 1996, Tables B-14 and B-15
		Machinery/equipment.	Undefined quantities.	These hazards are routinely encountered in industry.	--
High wind	All burial ground sites	High wind of sufficient velocity to suspend contaminated soil.	The maximum peak gust wind speed at Hanford was 129 km/hr (80 mph) (1972). The annual average for number of days with peak gusts in excess of 80 km/hr (50 mph) is 5.0 days. Winds in excess of 40 km/hr (25 mph sustained) occur slightly more than 1% of the time, on an annual basis.	Some fraction of the dry, contaminated soils will be suspended in air. High winds could cause debris to be thrown (a missile), causing a kinetic energy hazard or causing a "puff" release if this material strikes contaminated soil.	Hoitink et al., 2005, PNNL-15160

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Water intrusion	All burial ground sites	Liquids used for dust or fire suppression.	Undefined quantities.	The arid-to-semiarid climate suggests that little, if any, surface water will accumulate within the excavation. Most precipitation is lost through evapotranspiration. In addition, the transmissive nature of the surface soils allows rapid infiltration of precipitation. Consequently, little water remains to generate surface runoff. The quantities of water used for dust or fire suppression will be relatively minimal.	--
		Flooding from the Columbia River.	The maximum floods on record occurred in 1894 and 1948, with peak flows at the Hanford Site estimated at 21,000 m^3/s (27,468 yd^3/s) and 20,000 m^3/s, (26,160 yd^3/s) respectively (Neitzel 1997). These floods occurred before the Priest Rapids Dam and several other upriver dams had been constructed. The flow regulation resulting from the upriver dams significantly lessens the projected intensity of the potential 1,000-year flood to about 12,400 m^3/s, (16,219 yd^3/s) called a 1,000-year regulated flood. The regulated flood of 1997 was just under this level. Thus, a 1,000-year flood would not inundate any of the reactor areas or 100 Area burial grounds (DOE-RL 2005).	Spread of contamination could occur. The probable maximum flood of the Columbia River is not anticipated to inundate the 100-D/DR or 100-H Area.	1. Neitzel, D. A., 1997 2. DOE-RL, 2005

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Natural phenomena	All burial ground sites	Rainwater, snow, and ice.	Not applicable.	Spread of contamination could occur. The arid-to-semiarid climate suggests that little, if any, surface water will accumulate within the excavation. Most precipitation is lost through evapotranspiration. In addition, the transmissive nature of the surface soils allows rapid infiltration of precipitation. Consequently, little water remains to generate surface runoff.	DOE-RL, 2005

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Natural phenomena (cont.)	All burial ground sites	Seismic event.	A portion of the waste site could be impacted.	Falling debris, equipment, and heavy machinery could impact contaminated soil and result in a puff-like release. The severity of a seismic event at the Hanford Site is not anticipated to result in significant impacts to waste site structures. The effects of a seismic event on the Hanford Site or other facilities and projects would be much more significant than those consequences that would occur at the 100-D/DR and 100-H Burial Grounds. It is not anticipated that multiple accident events would be initiated as a result of a seismic event.	--
		Ash fall from volcanic activity.	Undefined quantities. During the May 18, 1980 eruption of Mount St. Helens, about 7.6 mm (0.3 in.) of ash was deposited at the Hanford Site. This resulted in a wet ash loading of only 20.4 kg/m^2 (4.2 lb/ft^2).	Historically, only minimal amounts of ash accumulation resulting from volcanic activity have occurred at the Hanford Site. This could result in coating of exposed surfaces at the excavation site; however, it would not result in a release of material.	--

Table A-1. 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds Remediation Hazard Identification Table. (12 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Natural phenomena (cont.)	All burial ground sites	Extreme temperatures.	Undefined quantities.	Temperature extremes range from -29 to 46°C (-20 to 115°F).	Hoitink, D. J. et al 2005, PNNL-15160,
		Lightning.	The average number of thunderstorms at the Hanford Site is 10, primarily occurring in June, July, and August.	Lightning could initiate a brush fire. See remarks for flammability and kinetic/potential energy hazard types.	Hoitink, D. J. et al., 2005, PNNL-15160,
Exposure	All burial ground sites	Radiological and hazardous materials exposure from debris/material (including direct exposure to high-energy gamma emitters such as cobalt-60). Exposed hardware included wire with graphite, spacers, pipes, and bottles.	Surveys of partially exposed hardware at the 118-B-1 site produced radiological exposure rate estimates that ranged from 500 mR/hr to 30 R/hr, on contact. These elevated exposure rates were found intermittently, not consistently, and were only associated with various parts of internal reactor hardware as they were unearthed. Similar exposure rates are expected at the 100-D/DR and 100-H Burial Grounds.	Various programmatic and safety and health controls are in place to protect the worker (e.g., personal protective equipment and the performance of area surveys).	0100D-CA-N0050 (WCH 2006a) and 0100H-CA-N0027 (WCH 2006b)
		Radiological dose rates from SNF.	Legacy SNF found at other burial grounds and fuel storage basins have experience dose rates from cesium-137 of up to 150 R/hr, but are commonly 30 to 40 R/hr on average.		

[a] "All burial ground sites" include the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground waste sites.
[b] Soft waste includes paper, masking tape, plastic, wiping rags, etc.
[c] Miscellaneous waste includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles, and miscellaneous reactor maintenance tools.

CFR = *Code of Federal Regulations*
N/A = not applicable
RQ = reportable quantity
SNF = spent nuclear fuel
TQ = threshold quantity

REFERENCES

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

40 CFR 68, "Chemical Accident Prevention Provisions," *Code of Federal Regulations*, as amended.

40 CFR 302, "Designation, Reportable Quantities, and Notification," *Code of Federal Regulations*, as amended.

40 CFR 355, "List of Extremely Hazardous Substances and Their Threshold Planning Quantities," *Code of Federal Regulations*, as amended.

DOE-RL, 1996, Appendix B, Table B-14, *Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-30-1496, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2005, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Hoitink, D. J., J. V. Ramsdell, K. W. Burk, and W. J. Shaw, 2005, *Hanford Site Climatological Data Summary 2004 With Historical Data,* PNNL-15160, Pacific Northwest National Laboratory, Richland, Washington.

Miller, R. L. and R. K. Whalen, 1987, *Estimates of Solid Waste Buried in the 100 Area Burial Grounds*, Tables 9, 10, 11 and B.7, WHC-EP-0087, Westinghouse Hanford Company, Richland, Washington.

Neitzel, D. A. (Ed.), 1997, *Hanford Site National Environmental Policy Act (NEPA) Characterization,* PNNL-6415, Rev. 9, Pacific Northwest National Laboratory, Richland, Washington.

WCH, 2006a, *Determination of Material at Risk and Hazard Screening for 100-D/DR Burial Grounds and Remaining Sites,* 0100D-CA-N0050, Rev. 1, Washington Closure Hanford, Richland, Washington.

WCH, 2006b, *Determination of Material at Risk and Hazard Screening for 100-H Burial Grounds and Remaining Sites*, 0100H-CA-N0027, Rev. 1, Washington Closure Hanford, Richland, Washington.

WCH, 2006c, *Evaluations and Comparisons of Various Spent Nuclear Fuel Inventories*, 0000X-CA-N0011, Rev. 0, Washington Closure Hanford, Richland, Washington.

APPENDIX B

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, AND 118-H-3 BURIAL GROUNDS REMEDIATION PROJECT HAZARD EVALUATION TABLE

APPENDIX B

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 BURIAL GROUNDS REMEDIATION PROJECT HAZARD EVALUATION TABLE

B.1 GENERAL METHODOLOGY

All events that could result in a potential release of hazardous substances were evaluated using the following approach:

- Events were grouped into three categories: operational/internal events, natural phenomena events, and external/man-made events.
- Events that were not applicable (e.g., flooding due to probable maximum flood, failure of engineered ventilation or filtration systems) were noted as not applicable (N/A).
- Frequency, Consequence, and Risk rankings were not assigned for events (such as loss of power to equipment) that could not result in a release of hazardous substances. These events are noted as not evaluated (N/E) in the corresponding columns.
- Consequence and Risk rankings were not assigned to events with an assigned unmitigated frequency of D, beyond extremely unlikely. N/E is noted in the corresponding columns.

B.1.1 Frequency Ranks

Frequency ranks were assigned using the following guidelines and the event frequency rank chart shown below.

- The frequency of the initiating event is the *unmitigated frequency*.
- Initiating events that involved human error were assigned an unmitigated frequency rank of A.
- Initiating events that involved failure of an active component were assigned an unmitigated frequency rank of A.
- Initiating events that involved failure of a passive component, were assigned an unmitigated frequency rank of B.
- Fire initiators involving use of an ignition source (e.g., vehicle exhaust systems, compressed gas torches) were assigned a frequency rank of A.

- Frequency assigned to natural phenomenon events assigned consistent with frequency of applicable evaluation basis event.
- Events that would not result in a potential release of hazardous substances (e.g., loss of power caused by vehicle accident) were not evaluated for frequency.

Event Frequency Ranks.

Term	Rank	Description	Frequency Range (yr-1)
Anticipated	A	May occur several times in the life of the facility	>1E-02
Unlikely	B	Not anticipated to occur during the life of the facility	1E-04 to 1E-02
Extremely unlikely	C	Probably will not occur in the life of the facility	1E-06 to 1E-04
Beyond extremely unlikely	D	All other events	<1E-06

B.2 CONSEQUENCE RANKS

Consequence ranks for the public, co-located worker, and facility worker were assigned based on anticipated unmitigated dose using the following charts. For events that were assigned a frequency of beyond extremely unlikely (event frequency D), the consequences were not evaluated.

Public Consequence Ranks.

Term	Rank	Dose Range	Concentration Range
High	1	>25 rem TEDE	>ERPG-2/TEEL-2
Moderate	2	1 to 25 rem TEDE	ERPG-1/TEEL-1 to ERPG-2/TEEL-2
Low	3	0.1 to 1 rem TEDE	<ERPG-1/TEEL-1 to ERPG-2/TEEL-2
Negligible	4	<0.1 rem TEDE	<ERPG-1/TEEL-1

ERPG = emergency response planning guideline
TEDE = total effective dose equivalent
TEEL = temporary emergency exposure limit

Co-Located Worker Consequence Ranks.

Term	Rank	Dose Range	Concentration Range
High	1	>100 rem TEDE	>ERPG-3/TEEL-3
Moderate	2	25 to 100 rem TEDE	ERPG-2/TEEL-2 to ERPG-3/TEEL-3
Low	3	1 to 25 rem TEDE	<ERPG-1/TEEL-1 to ERPG-2/TEEL-2
Negligible	4	<1 rem TEDE	<ERPG-1/TEEL-1

ERPG = emergency response planning guideline
TEDE = total effective dose equivalent
TEEL = temporary emergency exposure limit

Facility Worker Consequence Ranks.

Term	Rank	Exposure to Radioactivity or Other Hazardous Materials Characterization
High	1	Severe exposure resulting in prompt fatality or significant exposure (>100 rem TEDE or severe injury)
Moderate	2	Moderate exposure (10 to 100 rem TEDE, reversible health effects)
Low	3	Low exposure (1 to 10 rem TEDE, minor health effects)
Negligible	4	<Low

TEDE = total effective dose equivalent

B.2.1 Risk Ranks

Unmitigated frequency and consequence ranks were used to determine unmitigated risk ranks in accordance with the following chart.

Risk Ranks.

Consequence Rank	Frequency Rank			
	A	B	C	D
1	I	I	II	III
2	I	II	III	IV
3	III	III	IV	IV
4	IV	IV	IV	IV

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
OPERATIONAL/INTERNAL EVENTS (INITIATORS INTERNAL TO REMEDIATION ACTIVITIES)										
Fire	1A	Improper control of ignition sources	All sites	Soils, debris, and drums/containers contaminated with hazardous substances (radiological, fissionable, reactive, carcinogenic, toxics, corrosive, flammable/ combustible). Fuel storage tanks, cylinders, cabinets containing flammable/ combustible liquids.	Welding, cutting, grinding operations or improper control of other ignition sources (such as smoking) ignites flammable/combustible materials used or generated during remediation, resulting in an internal fire. The fire could result in a release of hazardous substances via entrainment. The fire could also cause an explosion (see item 2C). The fire could also cause an internal missile (see item 3A).	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Backflash arrestors and pressure regulators on welding equipment (P). Graded/graveled roadways minimize spread of fire (M).	Trained personnel (P). Safety/Fire Protection Program (see Note 1). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).
Fire	1B	Vehicle malfunction	All sites	See 1A	Vehicle malfunction causes vehicle fire. Vehicle fire ignites combustible/flammable material used or generated during remediation. The fire could result in a release of hazardous substances via entrainment. The fire could also cause an explosion (see item 2C). The fire could also cause an internal missile (see item 3A).	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Graded/graveled roadways minimize spread of fire (M). Separation of roads from remediation areas may prevent vehicle fire from causing release of hazardous substances (P).	Routine vehicle maintenance (P). Safety/Fire Protection Program (see Note 1). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Fire	1C	Vehicle accident	All sites	See 1A	Human error causes vehicle impact to flammable liquid storage tanks, cabinets, or pressurized gas cylinders, causing breach of tank/cabinets/cylinders and pooling of flammable/combustible liquids or gases. Introduction of an ignition source causes a fire resulting in a release of hazardous substances via entrainment. The fire could also cause an explosion (see item 2C). The fire could also cause an internal missile (see item 3A).	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage tank/ cylinder/ cabinet construction/ materials provides resistance to damage/ deterioration (P). Diking or double-walled tanks to contain liquids (P). Siting storage tanks/ cylinders/cabinets. • Away from remediation areas reduces potential involvement of wastes (P) (M). • In areas cleared of vegetation minimizes spread of fire (M).	Licensed vehicle operators (P). Hanford Fire Department response (M). Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).
Fire	1D	Chemical reaction/ autoignition of pyrophoric material	All sites	See 1A	Rapid oxidation of pyrophoric material (e.g., zirconium) occurs during handling of debris resulting in autoignition and a fire resulting in a release of hazardous substances via entrainment. Should fire occur with facility workers in the area, the release would not be confined and would be expected to disperse with air currents. Workers would move away, upwind, or evacuate the immediate area. Exposure to facility workers as a result of a fire is judged to be negligible. Although zirconium is a pyrophoric material, records indicate it is present as individual metal pieces from decladding events and process tube replacement, not as finely divided powders/fines required for explosive reactions. The potential for explosion and generation of an internal missile is judged negligible.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Explosion/ Flash Fire (see Note 3)	2A	Radiolytic or chemical decomposi-tion of waste (hydrogen)	All sites	See 1A	Radiolytic decomposition of water or hydrocarbon materials (e.g., mineral oil) or chemical decomposition in sealed drums/containers produces hydrogen. Inadvertent ignition during opening or handling of drums/containers results in burning or explosion/deflagration and release of hazardous substances via entrainment. Should ignition occur, a localized rapid burn (not rupture of the drum or ejection of its contents) is anticipated.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 3 Facility Worker: 1	IV III I	Use of intrinsically safe/nonsparking materials when opening sealed drums/containers (P).	Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Explosion/ Flash Fire (see Note 3)	2B	Multiple causes of pooled flammable/ combustible vapors/ gases	All sites	See 1A	A pool of flammable/combustible vapors/gases is caused by: • Vehicle accident (item 1C) • Human error during refueling operations, handling or use of flammable/combustible gases • Deterioration/damage of storage tanks/cylinders. Inadvertent introduction of an ignition source causes an explosion/deflagration resulting in a release of hazardous substances via entrainment. The explosion may also result in an internal missile (see item 3B). Although the frequency of an inadvertent release of flammable/combustible gases is anticipated due to human error, the frequency of an explosion that would result from these initiators is judged to be extremely unlikely. The remediation project uses relatively small volumes of flammable/combustible gases; accordingly, the potential for a release of a significant quantity of gas as a result of a human error is small. In addition, the gases are not stored in confined areas or buildings. The gases would be expected to rapidly disperse, thereby preventing accumulations at concentrations that would result in an explosion. Should ignition occur, a small, localized flash fire is more likely than an explosion.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage tank/cylinder/ cabinet construction/ materials provides resistance to damage/ deterioration (P). Siting storage tanks/ cylinders/cabinets. • Away from remediation areas minimizes potential for involvement with waste. • In areas cleared of vegetation minimizes spread of fire (M). • In unconfined outdoor areas minimizes collection of vapors/gases (P). Backflow preventers (P). UL-listed pumping equipment (P). Diking or double-walled tanks to contain liquids (P).	Licensed vehicle operators (P). Safety/Fire Protection Program (see Note 1). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Explosion/ Flash Fire (see Note 3)	2C	Fire	All sites	See 1A	A fire imparts energy sufficient to heat and pressurize fuel tanks, gas cylinders, flammable liquid storage cabinets, or sealed drums/containers, causing loss of integrity. The rupture/explosion results in a release and burning of contents, including hazardous substances if present, via entrainment. The explosion may also result in an internal missile (see item 3B). The potential for a fire imparting energy sufficient to cause rapid pressurization and rupture/explosion of tanks, cylinders, drums, or containers is judged unlikely. The contained materials provide a heat sink that will retard the heatup and pressurization rates, reducing the probability of catastrophic failure of the container, and violent ejection of contents. Vents may also be present (such as tanks and cylinders) or may be created by the heat up (such as popping of drum lids) that would further reduce the potential for catastrophic failure and ejection.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage tank/cylinder/ cabinet construction/ materials provides some protection (P). Proper venting of tanks/cabinets provides some protection (P). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens probability of involvement w/waste (M). Siting storage tanks/ cylinders/cabinets or drums in areas cleared of vegetation/ combustibles may prevent their involvement with fire (P).	Hanford Fire Department response (M). Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).
Internal Missile	3A	Fire	All sites	See 1A	Fire damages a pressurized cylinder, causing an internal missile. The internal missile impacts contaminated soil or debris, resulting in a puff-like release of hazardous substances via entrainment. The internal missile may also impact/rupture one or more waste drums/containers or fuel storage tanks/ cabinets, resulting in an airborne release of hazardous substances and spilling of contents (see item 9). The internal missile could also cause a secondary fire, explosion, spill, or release of material.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container construction/material s provides some protection (M). Storage tank/cylinder/ cabinet construction/ materials provides some protection (P). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens probability of involvement w/waste (M).	Use of dust suppressants/fixatives on contaminated soils/debris (M). Safety/Fire Protection Program (see Note 1). Spill response procedures (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Internal Missile	3B	Explosion	All sites	See 1A	An explosion causes an internal missile that may impact contaminated soil or debris, resulting in a puff-like release of hazardous substances via entrainment. An internal missile may also result in a rupturing of one or more drums/containers, resulting in an airborne release of materials and/or spilling of drum/container contents (see item 9). The internal missile could also cause a secondary fire, explosion, spill, or release of material.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container construction/materials provides some protection (M). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens probability of involvement w/waste (M).	Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response procedures (M). Radiation Protection Program (see Note 2).
Internal Missile	3C	Vehicle accident	All sites	See 1A	A vehicle accident impacts equipment or obstructions, causing an internal missile. The missile may impact contaminated soil or debris, resulting in a puff-like release of hazardous substances via entrainment. An internal missile may also result in a rupturing of one or more drums/containers, resulting in an airborne release of materials and/or spilling of drum/container contents (see item 9).	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container construction/materials provides some protection (M).	Spill response (M). Use of dust suppressants/fixatives on contaminated soils/debris (M). Maintaining roadways free of obstructions (P). Separation of normal roadways from active remediation and staging areas (P). Licensed vehicle operators (P). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Internal Missile	3D	Human error	All sites	See 1A	Mishandling of pressurized cylinders causes puncture or damage, resulting in an internal missile that may impact contaminated soil or debris resulting in a puff-like release of hazardous substances via entrainment. An internal missile may also impact and rupture one or more drums/containers, resulting in an airborne release of materials and/or spilling of drum/container contents (see item 9). An internal missile may also cause a secondary fire, explosion, spill, or release of hazardous substances.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Gas cylinder construction/materials provides some protection (P). Drum/container construction/materials provides some protection (M). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens probability of involvement w/waste (M).	Safety/Fire Protection Program (see Note 1). Use of dust suppressants/fixatives on contaminated soils/debris (M). Radiation Protection Program (see Note 2).
Loss of Power	4A	Vehicle accident	All sites	See 1A	Vehicle accident or other human error causes loss of power to electrically powered equipment. Although the majority of project activities are conducted outside and do not involve the use of filtered or negative pressure-controlled areas, some project activities such as waste size reduction and decontamination may use temporary enclosures, filters, and exhaust fans to minimize worker exposure. In these cases, a loss of electrical power would lead to a loss of negative pressure, and work would be suspended within the enclosure until power was restored. Because these activities do not require continuous manned operation, suspension of work would not initiate events that could lead to a significant release. Although the loss of negative pressure could lead to a small release of contamination outside the temporary enclosure, the energy driving the release is very low and the consequence of such a release is judged negligible.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Siting size reduction/ decontamination operations and electric supply lines away from heavy traffic areas reduces vehicle accident potential (P).	Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Loss of Power	4B	Equipment failure	All sites	See 1A	Failure of portable electrical generators causes loss of power to electrically powered equipment. Although the majority of project activities are conducted outside and do not involve the use of filtered or negative pressure-controlled areas, some project activities such as waste size reduction and decontamination may use temporary enclosures, filters, and exhaust fans to minimize worker exposure. In these cases, a loss of electrical power would lead to a loss of negative pressure, and work would be suspended within the enclosure until power was restored. Because these activities do not require continuous manned operation, suspension of work would not initiate events that could lead to a significant release. Although the loss of negative pressure could lead to a small release of contamination outside the temporary enclosure, the energy driving the release is very low and the consequence of such a release is judged negligible.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Preventive maintenance of portable generators reduces the likelihood of generator failure (P).	Radiation Protection Program (see Note 2).
Loss of Ventilation	5	Equipment failure	All sites	See 1A	Although the majority of project activities are conducted outside and do not involve the use of filtered or negative pressure-controlled areas, some project activities such as waste size reduction and decontamination may use temporary enclosures, filters, and exhaust fans to minimize worker exposure. Mechanical equipment failure could result in the release of a small amount of contamination from inside a temporary enclosure. Detection of equipment failure would result in a suspension of work within the enclosure until the equipment was repaired. Because these activities do not require continuous manned operation, suspension of work would not initiate events that could lead to a significant release. Although the equipment failure could lead to a small release of contamination outside the temporary enclosure, the energy driving the release is very low and the consequence of such a release is judged negligible.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Preventive maintenance of portable exhausters reduces the likelihood of mechanical failure (P).	Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Filter Failure	6	Filter failure	All sites	See 1A	Although the majority of project activities are conducted outside and do not involve the use of filtered or negative pressure-controlled areas, some project activities such as waste size reduction and decontamination may use temporary enclosures, filters, and exhaust fans to minimize worker exposure. Failure of a passive filter could result in the release of a small amount of contamination from inside a temporary enclosure. Detection of filter failure would result in a suspension of work within the enclosure until the filter was replaced. Because these activities do not require continuous manned operation, suspension of work would not initiate events that could lead to a significant release. Although the filter failure could lead to a small release of contamination outside the temporary enclosure, the energy driving the release is very low and the consequence of such a release is judged negligible.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Preventive maintenance of portable exhausters reduces the likelihood of filter failure (P).	Radiation Protection Program (see Note 2). Airborne filtration systems efficiency tested (P).
Dropped Load	7A	Human error	All sites	See 1A	Human error in rigging, lifting, or operating equipment causes load of soil, debris, or drum/containers to be dropped. Drop of soil or debris results in a puff-like release of hazardous substances via entrainment. Drop of drum/container results in rupture of drum, release of hazardous substances via entrainment, and spillage of contents (see item 9). Effect on fuel elements.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container construction/materials provides some protection (M).	Trained equipment operators and riggers (P). Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Dropped Load	7B	Equipment failure	All sites	See 1A	Equipment failure causes load of soil, debris, or drums/containers to be dropped. Drop of soil or debris results in a puff-like release of hazardous substances via entrainment. Drop of drum/container results in rupture of drum, release of hazardous substances via entrainment and spillage of contents (see item 9). Effect on fuel elements.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container construction/materials provides some protection (M).	Routine maintenance/ inspection of equipment (P). Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response (M). Radiation Protection Program (see Note 2).
Impact of Heavy Loads	8A	Human error	All sites	See 1A	Human error causes overturned vehicle or drop of heavy load/equipment. Impact on soil or debris results in a puff-like release of hazardous substances via entrainment. Impact on drums/containers result in rupture of drum/containers, release of hazardous substances via entrainment, and spillage of contents (see item 9). Effect on fuel elements.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Staging of excavated drums/containers away from heavy traffic areas (P).	Trained equipment operators and riggers (P). Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response (M). Radiation Protection Program (see Note 2).
Impact of Heavy Loads	8B	Equipment failure	All sites	See 1A	Equipment failure causes overturned vehicle or drop of heavy equipment. Impact on soil or debris results in a puff-like release of hazardous substances via entrainment. Impact on drums/containers result in rupture of drum/containers, release of hazardous substances via entrainment, and spillage of contents (see item 9). Effect on fuel elements.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Dedicated staging area for excavated drums/ containers away from heavy traffic areas (P).	Routine maintenance/ inspection of equipment (P). Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Spills	9	Multiple causes	All sites	See 1A	• Human error (vehicle accidents) • Internal missiles • Human error (dropped load/impact of heavy load) • Equipment failure (dropped load/impact of heavy load) may result in spill of hazardous substances, airborne release via entrainment, and spills of other liquids/solids. Spills of liquids from containers could result in a fire (see item 1D).	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Double-walled tanks provide some protection (P). Dikes, catch basins, other retention devices prevent spread (M). Staging of excavated drums/containers away from heavy traffic areas lessens potential for some spills (P). Drum/container construction/materials provides some protection (M).	Trained equipment operators and riggers (P). Licensed vehicle operators (P). Refueling instructions (P). Routine maintenance/ inspection of equipment and vehicles (P). Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response (M). Radiation Protection Program (see Note 2).
Corrosion	10	Environ-mental exposure	All sites	See 1A	Environmental exposure causes corrosion of drums/containers resulting in failure of drums/containers during excavation, handling, or storage. Failure of drums/containers results in release of hazardous substances via entrainment and spill of contents (see item 9).	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	Placing corroded drums/containers into overpacks may prevent subsequent failure of deteriorated drums (P). Spill response (M). Periodic inspection of drums/containers and overpacks for deterioration (P). Radiation Protection Program (see Note 2).
Structural Fatigue	11	N/A	N/A	N/A	Although drums/containers provide some protection from a spill or release of contents, engineered structures (such as buildings and ventilation systems) subject to structural fatigue are not relied on to prevent or mitigate a release of hazardous substances during remediation.	N/A	N/A	N/A	N/A	N/A

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Chemical Reaction	12	Excavation, handling, storage	All sites	See 1A	Excavation, handling, or storage of soils, debris, or drums/containers may expose waste materials that are reactive with air or incompatible with other materials. This exposure could cause a chemical reaction that would result in a release of hazardous substances via entrainment or spill. The reaction could also result in a fire. See item 1D for autoignition of pyrophoric materials. Concentrations of chemicals found in drums/containers are generally greater than concentrations found in soils and debris.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/containers construction/materials may prevent exposure to air or other incompatible materials (P).	Adding blanketing or stabilizing substances (e.g., water, sand, grout mineral oil) to pyrophoric materials (P). Use of drum/container overpacks to prevent loss of blanketing liquids. Segregation of waste streams may prevent exposure to incompatible materials (P). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).
Nuclear Criticality	13	Fissionable material	All sites	See 1A	A criticality screening performed for the waste site inventories concluded the concentrations of fissionable materials were such that the remediation activities could be executed with no criticality impact. Combinations of standard and non-standard elements and targets are allowed provided the sum of the fractions from each type together does not exceed unity. Using this basis, there are no normal or credible abnormal conditions that could result in criticality in either in a burial ground or in separated batches.	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evaluated	Not evaluated.	Criticality Safety Program.

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Internal Flooding	14	Fire/dust suppression	All sites	See 1A	Excess water used to suppress fires or dust causes accumulations that migrate beyond the remediation area, resulting in spread of contamination.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Runoff control measures, as necessary (ditches, dikes) (P).	Hanford Fire Department practices to minimize use of water inside waste site (P). Periodic radiological surveys would identify spread of contamination within the remediation area (P). Limited source of dust suppression water (tanker truck) (P). Remediation of contamination spread beyond boundaries (M). Radiation Protection Program (see Note 2).
Pipe or Vessel Rupture	15A	Vehicle accident	All sites	See 1A	Vehicle impact to fuel storage tanks, gas cylinders, or associated piping results in rupture, spill of contents, and possible fire. See item 1C for evaluation of fire. See item 9 for evaluation of spill.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage tanks construction/materials provides some protection (P). Dikes to contain spilled liquids (M). Double-walled tanks may prevent spill (P). Siting storage tanks away from heavy traffic would reduce probability of vehicle accident (P).	Licensed vehicle operators (P). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Pipe or Vessel Rupture	15B	Corrosion	All sites	See 1A	Environmental exposure causes corrosion of fuel storage tanks, gas cylinders, or associated piping that results in rupture, spill of contents, and possible fire. See item 1C for evaluation of fire. See item 9 for evaluation of spill.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Protective coatings on tanks/cylinders/piping prevent corrosion (P).	Periodic inspections of vessels/tanks for degradation (P). Safety/Fire Protection Program (see Note 1). Spill response (M). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).
Pipe or Vessel Rupture	15C	Over pressurization or blocked vent	All sites	See 1A	Blocked vent or relief valves cause over-pressurization (or internal vacuum during pumping) that results in rupture or fuel storage tanks or associated piping, spill of contents, and possible fire. See item 1C for evaluation of fire. See item 9 for evaluation of spill.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Provision of proper vents and reliefs to prevent over-pressurization or negative pressure during pumping (P). UL-listed pumping equipment (P).	Periodic inspections of vents/reliefs for obstruction (P). Safety/Fire Protection Program (see Note 1). Spill response (M). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
NATURAL PHENOMENA EVENTS (Events initiated by NPH)										
Lightning Induced Waste Site Fire	16	Lightning strike in waste site	All sites	See 1A	A direct lightning strike in the waste site could ignite flammable/combustible materials used or generated during remediation activities, resulting in a waste site fire. The fire could result in a release of hazardous substances via entrainment. A direct lightning strike could also impart enough energy to result in an explosion (see item 19). A direct lightning strike could also impart enough energy to result in an internal missile (see item 20).	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Proper grounding of flammable liquid storage tanks (P). UL-listed pumping equipment (P). Proper venting of storage tanks/ flammable liquid storage cabinets (P) (M). Graded/graveled roadways provide fire break (P) (M). Storage tank/cylinder/ cabinet construction/ materials provides some protection (P) (M). Siting storage tanks/ cylinders/cabinets in cleared areas away from remediation areas (P) (M).	Safety/Fire Protection Program (see Note 1). Hanford Fire Department response (M). Clearing remediation area of vegetation/ combustibles (P) (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Lightning Induced Range Fire	18	Lightning strike in vicinity	All sites	See 1A	A proximate lightning strike could initiate a range fire that enters the waste site. The range fire could ignite flammable/combustible materials used or generated during remediation activities. The fire could result in a release of hazardous substances via entrainment of hazardous substances.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Graded/graveled roadways provide fire break (P). Storage tank/cylinder/ cabinet construction/ materials provides some protection (P). Proper venting of tanks/cabinets provides some protection (P). Siting storage tanks/ cylinders/cabinets away from remediation areas (M). Siting storage tanks/ cylinders/cabinets in areas cleared of vegetation/ combustibles (P).	Clearing remediation area of vegetation/ combustibles (M). Hanford Fire Department response (M). Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).
Lightning Induced Explosion	19	Lightning strike in waste site	All sites	See 1A	A direct lighting strike on fuel tanks/gas cylinders/storage cabinets causes an explosion that results in a release of hazardous substances via entrainment. The explosion could also initiate a waste site fire (see item 17). The explosion could also result in an internal missile (see item 20).	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Proper grounding of flammable liquid storage tanks (P). Proper venting of storage tanks (P). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens potential involvement of wastes (M).	Periodic fire safety inspections for proper grounding, venting (P). Hanford Fire Department response (M). Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Lightning Induced Missile	20	Lightning strike in waste site	All sites	See 1A	A direct lightning strike causes an internal missile that may impact contaminated soil or debris resulting in a puff-like release of hazardous substances via entrainment. An internal missile may also result in a rupturing of one or more drums/containers, fuel tanks/cylinders/ cabinets resulting in an airborne release of materials and spill of contents (see item 9). The internal missile could also cause a secondary fire, explosion, spill, or release of material.	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage tank/cylinder/ cabinet construction/ materials provides some protection (P). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens potential involvement of wastes (M).	Use of dust suppressants/fixatives on contaminated soils/debris (M). Spill response (M). Hanford Fire Department response (M). Safety/Fire Protection Program (see Note 1). Radiation Protection Program (see Note 2).
Flooding	21A	Natural precipitation	All sites	See 1A	Heavy precipitation (rain or snow) causes localized puddles and flooding of the remediation areas, resulting in spread of hazardous substances from remediation area. Due to arid climate and high soil permeability, the potential for this occurrence is judged low.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	Routine radiological surveys for spread of contamination (M). Remediation of contamination areas (M). Radiation Protection Program (see Note 2).
Flooding-PMF	21B	Heavy rains/snow melt resulting in probable maximum flood	All sites	See 1A	The flow regulation resulting from the upriver dams significantly lessens the projected intensity of the potential 1,000-year flood to about 12,400 m^3/s, called a 1,000-year regulated flood. The regulated flood of 1997 was just under this level. Thus, a 1,000-year flood would not inundate any of the reactor areas or 100 Area burial grounds (DOE 2002) because of the regulated flows.	N/A	N/A	N/A	N/A	N/A

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Flooding-Catastrophic	21C	Breach of dams	All sites	See 1A	A flood caused by a 50% breach of the Grand Coulee Dam, caused by sabotage or war. This breach would cause a flow estimated at 600,000 m^3/s and would cause significant flooding, including (for the Hanford Reach area) the remainder of the 100 Areas, West Lake and Gable Mountain Pond, the 300 Area, and nearly all of Richland, Washington (DOE 1996). The potential effects from this scenario on waste sites have not been considered further because "…a breach under these conditions would indicate an emergency situation in which there might be other overriding major concerns" (Neitzel 1997).	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evaluated	Not evaluated.	Not evaluated.
Airborne Release Induced by High Wind	22A	High wind	All sites	Item 1A Contaminated soil, debris	High winds suspend contaminated soil or removable surface contamination on debris, resulting in airborne release via entrainment. High winds could spread contamination to offsite receptors.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	Use of dust suppressants/fixatives on contaminated soils/debris (M). Suspension of remediation activities during high winds (P). Routine air monitoring (P). Radiation Protection Program (see Note 2).
Airborne Release/ Spill Induced by High Wind Event	22B	High wind	All sites	Item 1A Contaminated drums/containers	High winds could suspend removable surface contamination from drums. High winds could spread contamination to offsite receptors. See item 9 for evaluation of spill. Tipover of drums/containers as a result of high wind is not anticipated due to their low center of gravity, mass, and geometry.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/containers and overpacks provide protection from spilling contents (M).	Prohibition on stacking of drums may prevent tipover (P) or damage to drums (M). Use of dust suppressants/fixatives on contaminated soils/debris (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Internal Missile Induced by High wind Event	22C	High wind	All sites	Item 1A Contaminated drums/containers	High winds could generate missile that may result in puncturing/rupturing one or more drums/containers or fuel tanks/cylinders/cabinets resulting in an airborne release of hazardous substances and spilling of contents. Wind-generated missiles that result in damage to drums/containers or fuel tanks/cylinders/cabinets and subsequent spill are not anticipated. Based on DOE (2002), Table 3-2, regarding wind design criteria, it is believed that the frequency of a peak gust wind speed sufficient to generate a missile that could breach a drum/ containers is less than 1E-02/yr on the Hanford Site. See item 3B for evaluation of internal missile.	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container and overpack construction materials provide some physical protection (M). Storage tank/cylinder/ cabinet construction/ materials provides some protection (P). Siting storage tanks/ cylinders/cabinets away from remediation areas lessens potential involvement of wastes (M).	Housekeeping of remediation area minimizes unnecessary materials that could become missiles (P). Spill response (M). Radiation Protection Program (see Note 2).
Airborne Release Induced by Seismic Event	23A	Earthquake	All sites	Item 1A Contaminated soils, debris	Seismic event causes ground movement and shaking of exposed remediation soils and debris, resulting in generation of minimal amounts of airborne hazardous substances as dust and spread of contamination. Due to excavation layback requirements (run/rise limited to 1.5:1) and moisture content, a seismic event is not anticipated to have sufficient energy to cause shifting of soil slopes.	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	Excavation layback requirements prevent slope shifts (P) (M). Hanford Emergency Response (M). Remediation of contamination spread (M). Use of dust suppressants/fixatives on contaminated soils/debris (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Impact of Heavy Load Induced by Seismic Event	23B	Earthquake	All sites	Item 1A Remediation equipment	Seismic event causes ground movement and shaking of excavation equipment, and impact to soils, debris, drums/containers. Overturn of remediation equipment, resulting in heavy load impact to soils, debris, and drums/containers is not anticipated due to the low center of gravity of remediation equipment. See items 8A and 8B for evaluation of heavy load impacts.	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Low center of gravity of remediation equipment provides some protection (M). Staging of excavated drums/containers away from heavy traffic areas minimizes potential damage (M).	Use of dust suppressants/fixatives on contaminated soils/debris (M). Hanford Emergency Response (M). Radiation Protection Program (see Note 2).
Rupture of Pipes/ Vessels Induced by Seismic Event	23C	Earthquake	All sites	Item 1A Fuel storage tanks/ cylinders/cabinets	Seismic event causes ground movement and shaking of fuel storage tanks/cylinders/cabinets, resulting in rupture and spill of contents. Breach of fuel storage tanks/cylinders is not anticipated due to construction and low center of gravity.	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage tank/cylinder/ cabinet construction/ materials provide some protection from damage (P). Use of double-walled tanks if appropriate (M).	Spill response (M). Radiation Protection Program (see Note 2).
Rupture of Drums/ Containers Induced by Seismic Event	23D	Earthquake	All sites	Item 1A Drums/containers	Seismic event causes minor ground movement and shaking of drums/containers, that may result in tipover, rupture of drums/containers, airborne release, and spillage of drum/container contents (see item 9). Tipover or sliding of drums/containers during earthquakes is not anticipated. BHI (2002), evaluated the seismic stability of drums in the staging area at ERDF and concluded sliding/tipover would not occur during the design basis event.	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Drum/container and overpacks construction and materials provide protection from rupture (P) and spilling contents if tipped over. (M).	Prohibition on stacking of drums lessens potential for tipover (P). Prohibition on stacking of drums lessen damage to drums (M). Spill response (M). Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Collapse of Drums/ Container, Fuel Tanks/ Cylinders Induced by Snow Load	24	Snow fall	All sites	Item 1A Drums/containers Fuel tanks/ cylinders/ cabinets	Snow blankets soil, debris, and drums with sufficient load to cause release of hazardous substances. Buildup of snow on excavated drums/containers is not anticipated to result in dead loads sufficient to collapse or breach drums/containers. Buildup of snow on fuel tanks/cylinders/cabinets is not anticipated to result in dead loads sufficient to collapse or breach them.	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evalu-ated	Not evaluated.	Not evaluated.
Collapse of Drums/ Containers, Fuel Tanks/ Cylinders Induced by Ash fall	25	Volcanic activity	All sites	Item 1A Drums/containers Fuel tanks/ cylinders/cabinets	Volcanic ash blankets soil, debris, and drums with sufficient load to cause release of hazardous substances. Buildup of ash on excavated drums/containers, fuel tanks/cylinders/cabinets is not anticipated to result in dead loads sufficient to collapse or breach drums/containers.	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evalu-ated	Not evaluated.	Not evaluated.

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
EXTERNAL EVENTS (MAN-MADE INITIATORS EXTERNAL TO REMEDIATION ACTIVITIES)										
Range Fire	26A	Vehicle or transportation accident	All sites	See 1A	A vehicle or transportation accident could initiate a range fire that enters the waste site. The range fire could ignite flammable/combustible materials used or generated during remediation activities. Equipment fuel/oil, drums holding flammable liquids, etc., would be available to propagate a fire. The fire could result in a release of hazardous substances via entrainment.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	Storage drums/tanks/ flammable liquid storage cabinets construction materials provide some resistance (P). Graded roads/fire lines inhibit spread of fire into remediation areas (P) (M). Proper venting of tanks/cabinets provides some protection (P) (M). Siting storage tanks/ cylinders/cabinets away from remediation areas (P) (M). Siting storage tanks/ cylinders/cabinets in areas cleared of vegetation/ combustibles (P).	Remediation/storage areas cleared of vegetation (P) (M). Minimization and proper storage of combustible materials (M). Flammable storage cabinets (M). Hanford Emergency Response Plan (M). Hanford Fire Department response (M). Radiation Protection Program (see Note 2).
Range Fire	26B	Proximate aircraft crash	All sites	See 1A	An aircraft crash could initiate a range fire that enters the waste site (see item 26A).	Public: B Coloc. Worker: B Facility Worker: B	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	See item 26A.	See item 26A.
Waste Site Fire	26C	Aircraft crash in the waste site	All sites	See 1A	The Hanford Site is subject to very limited aircraft traffic due to relative location of airports and normal air traffic patterns.	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evaluated	Not evaluated.	Not evaluated.

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Explosion	27A	Aircraft crash in the waste site	All sites	See 1A	The Hanford Site is subject to very limited aircraft traffic due to relative location of airports and normal air traffic patterns.	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evaluated	Not evaluated.	Not evaluated.
Explosion	27B	Aircraft crash in vicinity of waste site	All sites	See 1A	An aircraft crash in the proximate vicinity of the remediation area could result in an explosion and pressure pulse. Given the energy associated with such a crash, the resulting pressure pulse is judged insufficient to damage drums/containers, fuel tanks/cylinders/cabinets resulting in a release of hazardous substances.	Public: D Coloc. Worker: D Facility Worker: D	Not evaluated	Not evaluated	Not evaluated.	Not evaluated.
Loss of Power	28	Vehicle or transportation accident	All sites	See 1A	A vehicle or transportation accident causes a loss of power supply to the remediation site, resulting in possible interruption in remediation work. Loss of power does not result in release of hazardous substances as electrically powered systems are not relied upon to prevent or mitigate releases.	Public: A Coloc. Worker: A Facility Worker: A	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	None.

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin
Release of Hazardous Substances	29	Accident at nearby facility	All sites	N/A	Accident at nearby facility causes an airborne release of toxic materials. Depending on concentration and wind direction/stability, the release may result in deposition of hazardous substances in the remediation area. Interaction of the released substances with existing hazardous substances in the waste sites is not anticipated. Initiation of emergency procedures at the nearby facility would result in the appropriate notification or evacuation of remediation workers. The remediation activities do not include the operation of processes, equipment, or systems that require continuous manned operation. There are no monitored processes or operations that cannot be suspended and workers evacuated.	Public: C Coloc. Worker: C Facility Worker: C	Public: 4 Coloc. Worker: 4 Facility Worker: 4	IV IV IV	None.	Hanford Emergency Response Program. Radiation Protection Program (see Note 2).

Table B-1. Evaluation of Hazards Associated with the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Ground Remediation Activities. (25 Pages)

Event Type	Item Number	Summary				Unmitigated Risk			Prevention (P) and Mitigation (M)	
		Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	SSCs	Admin

NOTE 1: Safety/Fire Protection Program procedures (S/FPP) include, as appropriate:

- Hot work permits (P) that require protection or movement of combustible materials (P), and fire watch with extinguisher and means to notify Hanford Fire Department (M)
- Fire Marshal Permits for installation, storage, use, or handling of flammable/combustible liquids (based on type and volume of flammable/combustible liquids (P), including restrictions on smoking (P) and refueling operations (P), and measures for containment of liquids (dikes/catch basins, double-wall tanks, or combination thereof)
- Fire Marshal permits for siting/construction of membrane structures and tents, and other portable structures (e.g., trailers)
- Use of UL-listed flammable/combustible liquid pumping equipment (P)
- Periodic inspections for control of ignition sources (P), control of combustibles (P), removal of excess combustibles (P)(M), and material condition of flammable/combustible liquid storage tanks;
- Provisions for storage of flammable/combustible gasses (P) including separate storage of fuels and oxygen, chains, and caps (P)
- Appropriate provisions are identified for opening bulged or sealed drums/containers, that include as appropriate - limiting number of drums handled at one time, use of intrinsically safe/nonsparking materials and remote apparatus to open, separation from other drums/containers prior to opening (P) (M)
- Appropriate provisions for storing excavated drums/containers, that include as appropriate - use of noncombustible overpacks and staging materials (P), and use of nonflammable/combustible blanketing or stabilization substances (P) (M).

NOTE 2: Radiation Protection Program procedures include, as appropriate:

- Monitoring and survey methods to detect the spread of radioactive contamination to minimize or prevent its release during a proximate event (P) and to mitigate the potential for additional release of material after an event (M)
- Instructions to suspend work in outdoor radiological areas when visible airborne dust is present (P) (M)
- Provision for storage of radioactive material in designated locations and in containers appropriate for radiological hazards (P) (M)
- Conduct of operations and personal protective equipment (PPE) for work in radiological areas to minimize or prevent exposure and intake (P) (M)
- Training to ensure appropriate response to radiological hazards.(M).

NOTE 3: As defined in NFPA 1991, an explosion is a rapid release of high-pressure gas into the environment. The events of concern in this evaluation involve a propagating reaction that begins at a specific point (i.e., ignition point) and then propagates through the unreacted material. Propagation may generate a flash fire or an explosion that propagates either subsonically (deflagration) or supersonically (detonation) (AIChE 1989). The energy release rate of this type of event is dependent on the propagation rate, which, in turn, is dependent on the combustible concentration. Propagation occurs rather slowly near the limiting combustible concentrations (e.g., lower explosive limit) and increases to a maximum near stoichiometry. Any such event at the burial ground is expected to be a flash fire or a deflagration with small pressure generation.

ERDF = Environmental Restoration Disposal Facility
N/A = not applicable
SSC = systems, structures, and components
UL = Underwriters Laboratories

B.3 REFERENCES

AIChE, 1989, *Guidelines for Chemical Process Quantitative Risk Analysis*, Center for Chemical Process Safety of the American Institute of Chemical Engineers, New York, New York.

BHI, 2002, *Evaluation for Seismic Stability of Containers for Uranium Metal and Uranium Oxide at ERDF*, Calculation No. 0200W-CA-C0164, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE, 1996, *Standard Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-3014-96, U.S. Department of Energy, Washington, D.C.

DOE, 2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, DOE-STD-1020-2002, U.S. Department of Energy, Washington, D.C.

Neitzel, D. A. (Ed.), 1997, *Hanford Site National Environmental Policy Act (NEPA) Characterization,* PNNL-6415, Rev. 9, Pacific Northwest National Laboratory, Richland, Washington.

NFPA, 2000, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies*, National Fire Protection Association, Quincy, Massachusetts.

APPENDIX C

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, AND 118-H-3 FINAL HAZARD CATEGORIZATION

CALCULATION COVER SHEET

Project Title 100-D/DR/H Field Remediation **Job No.** 14655

Area 100-D/DR and H Area

Discipline Nuclear/Safety Engineering ***Calc. No.** 0100X-CA-N0020

Subject 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation

Computer Program Excel **Program No.** 2003

The attached calculations have been generated for a specific purpose and task. Use of these calculations by persons who do not have access to all pertinent facts may lead to incorrect conclusions and/or results. Before applying these calculations to your work, the underlying basis, rationale, and other pertinent information relevant to these calculations must be thoroughly reviewed with appropriate Washington Closure Hanford LLC (WCH) officials or other authorized personnel. WCH is not responsible for the use of a calculation not under its direct control.

Committed Calculation ☒ **Preliminary** ☐ **Superseded** ☐ **Voided** ☐

Rev.	Sheet Numbers	Originator	Checker	Reviewer	Approval	Date
0	Cover – 1 Calc. – 36 Total - 37	T. J. Rodovsky (via email) 2/21/06	T. M. Blakley	M. F. Maxson	J. S. Decker	2/23/06
1	Cover – 1 Calc. – 38 Total – 39	T. J. Rodovsky	J. D. Ludowise 11-7-06	M. F. Maxson 11/7/06	J. S. Decker	11/8/06

SUMMARY OF REVISION

1	Delete reference to average weight of fuel element. Changes incorporate DOE comments (CCN 127946). DOE comments included changing the 1) high wind/entrainment of contaminated liquid R value of 3.2E-05, 2) deflagration of contaminated combustible solids to an R value of 1E-03, 3) dropping/impact of contaminated combustible solids R value to 1E-03. All postulated accident scenarios, not only fire and deflagration are now analyzed. Pagination has significantly changed.

WCH-DE-019 (04/14/2006) *Obtain Calc. No. from R&DC and Form from Intranet

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TJR	**Date:** 11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:** 14655	**Checked:** J. D. Ludowise JDL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			**Sheet No.:**	1 of 38

1.0 Table of Contents

0100X-CA-N0020_FHC_Rev0_markup -4/Calc (1) (TOC)

Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky TR	**Date:** 11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:** 1		
Project: D/DR/H Field Remediation	**Job No.:** 14655	**Checked:** J. D. Ludowise JDL	**Date:** 11-7-06		
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			**Sheet No.:** 2 of 38		

2.0 Results:

The 1027 Category 3 sum-of-the-ratios for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds is summarized below for all the postulated events for the bounding waste site (the 118-D-3). The sums of the Category 3 TQ ratios for each waste form and hazard scenario are listed below.

Waste Form	Dumping	Entrainment	Deflagration	Dropping / Impact	Fire
Soil	3.46E-04	3.43E-03	3.43E-04	3.46E-04	3.43E-02
Liquid	4.65E-03	3.14E-03	3.32E-03	4.65E-03	5.01E-02
Combustibles	Insignificant	6.79E-03	1.29E-03	1.29E-03	6.79E-02
Noncombustibles	2.06E-02	2.06E-01	1.96E-03	2.06E-02	2.51E-02
Spent Fuel Elements (Oxide)	2.18E-02	2.18E-02	4.36E-02	2.18E-02	1.39E-03
Spent Fuel Elements (Metal)	Insignificant	Insignificant	Insignificant	Insignificant	2.26E-01
Sum	**4.74E-02**	**2.41E-01**	**5.05E-02**	**4.87E-02**	**4.05E-01**

The above sum of the ratios values are conservatively based on all the postulated events that impact the inventory of each of the waste forms. Since the sum of all of the waste forms for each accident scenario is below 1, the designation for each of the burial grounds is below Category 3.

3.0 Purpose:

The purpose of this calculation is to evaluate radionuclide constituents to determine the Final Hazard Categorization (FHC) for the 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Burial Grounds.

4.0 Assumptions

The burial grounds contain a mixture of materials contaminated with radionuclides. These materials are particulate materials (e.g., soil, oxide from damaged spent fuel elements), noncombustible solids (e.g., metals, concrete), and combustible solids (e.g., wood, paper, cardboard) that may be either containerized or loose within the burial ground. A potential also exists for containerized liquids to be present within the burial grounds.

The accident scenarios analyzed for this site are high wind, fire, deflagration, dumping and dropping/impact events, which are assumed to cause a release of contaminated material.

Past excavations at the 100 Area burial grounds have unearthed spent nuclear fuel elements (i.e. 118-B-1 and 118-C-1). This calculation conservatively assumes a bounding inventory of 25 spent fuel elements at each waste site. This number is based on the number of "standard" plutonium production elements (25) found during remediation of the 105-F and 105-H Fuel Storage Basins (FSB). Based on the condition of the fuel elements found at the 105-F and 105-H FSBs and at the 118-B-1 and 118-C-1 Burial Grounds, it is assumed that 20% of the fuel elements are damaged. This damage is manifested in the form of an oxide layer that equals 0.1% of the total inventory of the elements. The 0.1% oxide fraction is consistent with assumptions used for fuel at 105-H FSB (BHI 2000) and the 100-B/C Burial Ground ASA (BHI 2005c). The inventory of the standard elements was shown to be conservative for single-pass reactor elements during the approval process for BHI (2000) as documented by CCN 084171. The isotopes not included in the inventory (e.g., U-235) are negligible contributors to radiological consequences.

In addition to the standard fuel elements, non standard fuel elements were also evaluated. The non-standard fuel element inventory is determined in calculation BHI 2005a and the associated white paper BHI 2005b.

MOC-2002-0010, "Potential Presence of Special Fuel Elements in 105-H Fuel Storage Basin," [BHI 2002c] evaluated the potential radiological dose consequences of standard plutonium production elements compared to the non-standard elements. The standard element was determined to bound any airborne release event (i.e., inhalation pathway, food ingestion pathway) because of the significantly larger inventory of plutonium (and americium) in the standard element compared to the non-standard elements. The standard element was also determined to bound a direct dose event based on the relative Cs-137 content of each type of element and Cs-137 being responsible for about 98% of the direct dose.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TR	**Date:** 11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:** 14655	**Checked:** J. D. Ludowise JDL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			**Sheet No.:**	3 of 38

4.0 Assumptions (continued)

Accident scenarios for dumping, entrainment, deflagration, dropping/impact, and fire are evaluated in this calculation. Assumptions for each of these events are included in the following table:

Waste Type	Entrainment (High Wind) Event	Fire Event (due to any initiator)	Deflagration Event	Dumping/ Spilling Event	Dropping / Impact
Soil	High winds impact and resuspend contaminated soil during excavation activities.	Fire event is judged to have negligible impact on contaminated soil.	Deflagration event is judged to have negligible impact on contaminated soil.	Dumping/dropping of contaminated soil during excavation activities causing a release.	Excavation equipment or vehicles could impact contaminated soil and cause an airborne release.
Spent Fuel Element (Oxide)	High wind event could resuspend loose oxide on spent fuel elements.	Fire has the potential to heat the fuel element oxide causing a release of existing oxide.	Pressure rise resulting from a deflagration of flammable gas/air mixture during excavation activities could cause a release of existing oxide materials.	Release of oxide materials could occur as a result of a drop/impact.	Excavation equipment could impact the fuel elements causing a release of existing oxide.
Spent Fuel Element (Metal)	No significant airborne release.	Severe fire could oxidize some fraction of the metal.	No significant airborne release.	No significant airborne release.	No significant airborne release.
Contaminated Combustible Solids	High wind event could resuspend loose surface contamination from soft wastes contained within the burial grounds.	Soft wastes could be ignited during a fire event causing a release of contaminated materials.	Pressure rise resulting from a deflagration of flammable gas/air mixture during excavation activities could cause a release of surface contamination.	No significant release of contaminated materials from this type of solid (e.g., soft wastes) is expected due to high surface area to mass ratio.	Vehicle/equipment impact to packaged, contaminated soft wastes could result in a suspension of loose surface contamination.
Contaminated, Noncombustible Solids	High wind event could resuspend loose surface contamination from buried debris.	Fire has the potential to heat these solids causing a release of surface contamination. Majority of waste will be protected from heat of fire due to location below grade.	Pressure rise resulting from a deflagration of flammable gas/air mixture during excavation activities could cause a release of surface contamination.	Damage/dropping of contaminated materials could result in a release of loose surface contamination.	Excavation equipment or vehicle could impact buried debris causing a release of loose surface contamination.
Containerized liquids	High wind could cause a spill of containerized liquids.	Fire event has the potential to impact containerized liquids and cause a release.	Deflagration event has the potential to impact containerized liquids and cause a release.	Dumping/dropping of containerized liquid during excavation activities could occur causing a release.	Excavation equipment or vehicles could impact containerized liquid and cause a release.

5.0 Methodology:

The following is a list of the steps involved in determining the FHC for each site:

Step 1: Determine contaminated material inventories.

Contaminated inventories, which were used in the initial hazard categorization, are documented in calculation 0100D-CA-N0050 (WCH 2006b) for the 100-D sites and 0100H-CA-0027 (WCH 2006a) for the 100-H sites . Only radionuclides are used in determining the FHC; therefore, analysis of chemical constituents is not included in this FHC calculation.

Step 2: Calculate the revised TQ values ($TQ_{REVISED}$)

The hazard Category 3 threshold quantities (TQ) in DOE-STD-1027-92 (DOE, 1997) are based on the release values (RV) calculated in (EPA, 1989.) Release values are determined for each of four exposure pathways: food ingestion, water ingestion, inhalation, and direct exposure. The TQ for a given isotope is 20 times the most restrictive RV. The TQ can be expressed as:

$$TQ = 20 \times MIN\{ RV_{FOOD}, RV_{WATER}, RV_{INH}, RV_{DIR} \} \quad (1)$$

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky *(via email)*	**Date:**	2/21/2006	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	0
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	T. M. Blakley	**Date:**	2/21/2006
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	4 of 36

5.0 Methodology (continued):

Step 2: Continued

The EPA methodology uses the following assumptions:

1) The RV for the water ingestion pathway assumes that 100% of the material is released to drinking water (see EPA, 1989 Appendix B.1)
2) The RV for the inhalation pathway and the RV for the food ingestion pathway both are inversely proportional to a respirable airborne release fraction (see EPA, 1989 Appendix A.2 and Appendix C.1).
3) The RV for direct exposure for isotopes other than noble gases assumes a point source

The DOE Office of Nuclear and Facility Safety Policy Nuclear Safety Technical Position, NSTP 2002-2 (DOE, 2002), allows that the hazard Category 3 TQs for radionuclides for which the food pathway and the inhalation pathway are limiting may be revised if, based on the physical and chemical form and available dispersive energy sources for the facility and its hazardous materials, the credible release fractions (airborne release fractions) can be shown to be significantly different from the values used in the EPA Technical Background Document. All potential accident scenarios must be considered under unmitigated conditions. All pathways must be considered and the most limiting pathway must be used.

Based on the guidance in NSTP 2002-2, the revised Category 3 TQ for an isotope in a particular material form can be expressed as:

$$TQ_{Revised} = 20 \times MIN \{ f_1 \times RV_{FOOD}, f_2 \times RV_{WATER}, f_1 \times RV_{INH}, f_3 \times RV_{DIR} \} \qquad (2)$$

Where

Where	f_1	is the ratio of the respirable airborne release fraction used in the EPA analysis (from EPA, 1989 Exhibit A-1) to the largest respirable airborne release fraction from any potential accident
	RV_{FOOD}	is the release value for the food pathway from EPA, 1989 Appendix E
	f_2	is the ratio of the fraction of material released to drinking water in the EPA analysis (i.e., 1) to the largest fraction of material released to drinking water in any potential accident scenario
	RV_{WATER}	is the release value for the water pathway from EPA, 1989 Appendix E
	RV_{INH}	is the release value for the inhalation pathway from EPA, 1989 Appendix E
	f_3	is the ratio of the dose rate from a point source at 30 meters to the dose rate from a distributed source of equal activity at 30 meters
	RV_{DIR}	is the release value for the direct exposure pathway from EPA, 1989 Appendix E

The potential accident scenarios and corresponding release fractions are identified from a hazard analysis. This final hazard categorization will be based on the hazard analysis in Roberson (2002) and the scenario analyses presented in WCH 2005a. These analyses form the basis for identifying appropriate respirable airborne release fractions. The release fractions will be from DOE-HDBK-3010-94 (DOE, 2000), Roberson (2002), or other analyses previously approved by DOE. Equation 2 will be used to generate revised TQs for each constituent present at each burial ground.

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Originator:	T.J. Rodovsky *(via email)*	**Date:**	2/21/2006	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	0
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	T. M. Blakley TMB	**Date:**	2/21/2006
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	5 of 36

5.0 Methodology (continued):

Step 2: Continued

The total inventory of radionuclides in each material form is compared to the revised TQs for that form using the sum of the ratios. The final hazard categorization is based on the accident scenario yielding the bounding (i.e, maximum) sum-of-the-ratios. Since it is possible that a specific accident scenario could impact several waste forms (i.e., combustibles, noncombustibles, and spent fuel elements), the individual sum-of-the-ratios for all waste forms have been combined to determine the bounding sum-of-the-ratios.

For conservatism, this final categorization will assume that f_2 is equal to 1 although there is no potential for releases to drinking water in the vicinity of the waste site. It will also assume that f_3 is equal to 1, although the point source model is quite conservative for the large distributed sources present at the Burial Grounds.

The adjustment factor f_1 can be expressed as: $f_1 = R_{EPA}/R_{HA}$.

Where,

R_{EPA} is the respirable release fraction for a hazardous material element (e.g., cobalt, aluminum, strontium) from EPA (1989), Exhibit A-1.
R_{HA} is the respirable release fraction for a particular hazardous material for the potential hazard identified in this hazard analysis.

In general, the respirable release fraction (R) is the product of the airborne release fraction (ARF) and the release fraction (RF), or R = ARF x RF.

Step 3: Determine the final hazard categorization for each waste site.

The inventories for each constituent are divided by the revised TQ values. The individual waste form (or combined waste forms impacted by a specific accident) yielding the bounding sum-of-the ratios for each waste site is compared to 1. If the sum of the ratios is above 1 using the revised TQ, then the revised TQ has been exceeded and the FHC for the waste site is determined to be Category 3. If the sum of the ratios is below 1, the FHC is determined to be below Category 3.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky DL	**Date:**	11/7/06	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	J. D. Ludowise JDL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	6 of 38

6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms

Waste Site Descriptions

118-D-1 (100-D Burial Ground Number 1) - The 118-D-1 Burial Ground is an inactive solid waste site that operated from 1944 to 1967. The 137- by 114-m (450- by 375-ft) site was located approximately 274 m (900 ft) south of the 105 DR Building. The burial ground was used to dispose of irradiated reactor parts, dummies, thimbles, rods, gun barrels, and other contaminated solid waste. The burial ground contains several trenches running north and south, but the exact number is unknown. The trenches were 91 by 6 by 6 m (300 by 20 by 20 ft) deep with a 6-m (20–ft) space between them. The unit received an estimated 10,000 m^3 of wastes. The burial ground was divided into four sections to allowing grouping of like waste in each section (Hanford Drawing H-1-4046).

118-D-2 (100-D Burial Ground Number 2) - The 118-D-2 Burial Ground is an inactive solid waste site that operated from 1949 to 1970. The 305- by 109- by 6 m (1,000 by 357 by 20-ft)-deep site is located approximately 823 m (2,700 ft) southwest of the 105-DR Building. The burial ground was used for disposal of an estimated 10,000 m^3 of miscellaneous contaminated solid waste, irradiated dummies, splines, rods, thimbles, and gun barrels. It is divided into four sections to allow grouping of like wastes (Hanford Drawing H-1-4046).

Beginning in April 1966, 100-N Area low-level radioactive solid wastes were also buried at this site. The site containsseveral trenches running east-west (the exact number is unknown) and five disposal pits. The trenches are 20 m (66 ft) wide at the surface, 6 m (20 ft) wide at the bottom, and 6 m (20 ft) deep. Each trench is composed of two small pits, constructed with railroad ties, with interior dimensions of about 1.8 by 1.8 m (6 by 6 ft), placed within an excavation 7.3 by 7.3 m (24 by 24 ft) deep. All were covered with 1.8 m (6 ft) of soil. Historical documents report that there was a fire in this burial ground in March of 1958 (reference HW-55462). The fire was difficult to extinguish and required large volumes of water (several tank truck loads) to put out, therefore, contaminants could potentially have been washed to the soil column beneath this burial ground.

118-D-3 (100-D Burial Ground Number 3) - The 118-D-3 Burial Ground is an inactive solid waste site that operated from 1956 to 1973. This burial ground was located approximately 107 m (350 ft) east of the 105-DR Building. Typically, trenches were 61 by 6 by 6 m (200 by 20 by 20 ft) deep, and the spacing between trenches was not uniform. This burial ground was divided up into five sections to allow grouping of like wastes (Hanford Drawing H-1-4046). It also contained a burning pit that was used for the disposal of low-level radioactive combustible wastes. The burial ground was used for the disposal of miscellaneous contaminated solid wastes and irradiated dummies, splines, rods, thimbles, and gun barrels.

The site was also used for disposal of 100-N solid wastes, extending the eastern boundary. Two additional solid waste burial ground sites in or very near this burial ground are considered a part of it. These being the Minor Construction burial ground number 2 and the "grave." The Minor Construction burial ground number 2 was a trench dug in 1953 to receive contaminated thimbles, rod guides, and miscellaneous waste removed from the 105-DR Reactor during an extended Ball 3X shortage. The contaminated wastes were then covered with 1.8 m (6 ft) of dirt. The "grave" was a small trench dug in March 1954 to receive effluent water from the number one DR west effluent expansion box during repairs. The trench received specific wastes and was covered as soon as the waste was received. It is assumed that the trench was dug very near the expansion box and should be located in the northwest corner of the burial ground.

118-H-1 (100-H Burial Ground Number 1) - 118-H-1 is an inactive mixed solid waste burial site that is recognized as having been the primary burial ground for the 100-H Area. It is located approximately 396 m (1,300 ft) southwest of the 105 H Reactor Building. This site operated from 1949 until 1965 and received an estimated 10,000 m^3 of waste from 100-H Reactor operations. The site received reactor process tubing, dummy fuel elements, contaminated lead brick, and other reactor hardware. The burial ground was enlarged in 1955. The total dimensions were 213 m (700 ft) long by 107 m (350 ft) wide and 61 m (20 ft) deep. The numerous trenches in the east/west-oriented burial ground run north to south. Trench layout details may be seen on Hanford Site Drawing H-1-13484. Cross-sectional details and wooden crib design are provided on Hanford Site Drawing P-3475. The site is primarily backfilled with 1.8 m (6 ft) of soil cover. Near the southwest corner, portions of several horizontal controls rods are buried in slit trenches with 0.6 to 1.2 m (2 to 4 ft) of soil cover. A fire at the site occurred in October of 1960 (HW-67034).

118-H-2 (100-H Burial Ground Number 2) (H-1 Loop Burial Ground) (P-13 Pit) - 118-H-2 is an inactive, solid mixed waste burial ground located approximately 457 m (1,500 ft) west of the 105-H Reactor Building. The site operated from 1955 to 1965 to receive a small volume of contaminated and activated test material and contaminated pipe. The burial ground was about 43 m (140 ft) long, 15.2 m (50 ft) wide, and 4.6 m (15 ft) deep when excavated in 1955.

Two concrete vaults were placed in the excavation to receive activated and contaminated hardware associated with an experimental reactor test facility, reportedly on behalf of the U.S. Navy. The easternmost vault was used for this purpose in 1955 when a test loop, or "stainless steel double tube" was transferred from the reactor to this vault for burial after several years of irradiation. Additional information on the "P-13" assembly project can be found in HW-36063 and HW-46124. The second vault, constructed in 1958 to the west of the first vault, was intended for a similar use but was not used in the program. A small quantity of contaminated pipe was placed in it at the time of reactor deactivation in 1965. Both vaults were filled with gravel and the excavation was backfilled to grade. Additional clean soil has since been added to form a berm that rises approximately 0.9 m (3 ft) above grade over the burial ground.

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Waste Site Descriptions (continued):

118-H-3 (Construction Burial Ground) - The 118-H-3 Burial Ground is an inactive solid mixed waste burial ground located approximately 244 m (800 ft) southeast of the 105-H Reactor Building. It operated from 1953 to 1957 and received approximately 3,000 m^3 of reactor components and hardware, including lengths of contaminated 16 in. pipe that were used as chutes for the removal of reactor vertical safety rod thimbles and other components from reactor modification programs. The burial ground is 91 m (300 ft) long, 61 m (200 ft) wide, and 6 m (20 ft) deep. It consists of multiple north/south running trenches that have been backfilled to grade with approximately 1.8 m (6 ft) of soil.

Accident Scenarios Evaluated:

This FHC calculation evaluates several types of accident scenarios including dumping/entrainment of contaminated materials, deflagration impacting waste and spent fuel elements, dropping/impact of burial ground contents including fuel elements, and exposure of the burial ground contents to a fire. Each of these scenarios is summarized in the following sections:

6.1 Dumping

Contaminated Soil: The respirable ARF for soil dumping used in Roberson (2002) Attachment 4 is 1.0E-06. The RF value for contaminated soil is 1; therefore, the **R value used for dumping of contaminated soil is 1.0E-06**.

Contaminated, Combustible Solids: Contaminated combustible solids may be lifted out of a trench and dropped. These combustible materials are typically lightweight. Consequently, they would generate little force during impact with surfaces. DOE (2000), Section 5.2.3.1, states that no significant suspension of surface contamination is postulated for such materials. Dumping of contaminated combustible solids is not considered further in this calculation.

Contaminated, Noncombustible Solids: Contaminated, noncombustible solids may be lifted out of a trench and dropped, or digging equipment may impact them. DOE (2000), Section 5.3.3, addresses free-fall spill and impaction stress to such solids. The bounding ARF for shock-vibration of contaminated noncombustible materials that do not undergo brittle fracture is 1.0E-03. The respirable fraction is assumed to be 1.0; therefore, **the R value used for this scenario is 1.0E-03**.

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6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms

6.1 Dumping (continued)

Contaminated liquid: The potential exists for containers of liquid to be found in the burial grounds. It is possible that such containers could be spilled during remediation activities. The amount of liquid is expected to be a small fraction of the total volume of the burial trenches. Section 3.2.3.2 of DOE (2000) indicates that a spill of aqueous solutions, subjected to a 3-m fall distance, has a bounding **R value of 1.0E-04.**

Spent Fuel Elements: Dumping of spent fuel elements could cause an airborne release of surface oxide. No release from metallic portion of spent fuel elements would occur. It is assumed that the release of oxide is similar to that of contaminated, non-combustible solids. Therefore, **the R value for release of oxide due to dumping is 1.0E-03.**

6.2 High Wind/Entrainment

The soil entrainment rate used in Attachment 4 of Roberson (2002) is 4.0E-03 g/m2-h. The surface areas for the six sites discussed in this calculation are shown below and were obtained from historical design drawing of the sites.

118-D-1: 9,009 square-meters
118-D-2 12,970 square-meters
118-D-3: 16,455 square-meters
118-H-1: 27,738 square-meters
118-H-2: 1,941 square-meters
118-H-3: 11,748 square-meters

Of the six burial ground sites discussed in this calculation, the 118-H-1 site has the largest surface area of this six sites. This site will be conservatively used to maximum the rate of intrainment value, but the 118-D-3 inventory will be used because it has the bounding inventory.

118-D-3 Contaminated Soil: Assuming a density of 2.27 g/cm^3 or 2.27E+06 g/BCM for the contaminated soil at the 118-D-3 Burial Ground, and a soil volume of 80744 BCM (0100D-CA-N0050), the total mass of contaminated soil at the 118-D-3 Burial Ground is 1.83E+11g. As discussed above, the surface area of the 118-H-1 burial trenches is 27,738 m^2. Assuming that the entire surface area of the trenches is exposed to wind, the rate of entrainment of contaminated soil would be as follows:

$$\chi = 27{,}738 \text{ m}^2 \times 0.004 \text{ g/m}^2\text{-h} = 111 \text{ g/h}$$

Over 24 hours, this translates to 2660 g of soil entrained. Therefore, the respirable ARF for a 24-hour period would be as follows:

$$\mathbf{R} = \text{ARF} \times \text{RF} = 2660 \text{ g} / 1.83\text{E}{+}11 \text{ g} = \mathbf{1.5E\text{-}08}$$

Therefore, the entrainment value above will be used in this calculation; **R = 1.5E-8.**

Contaminated, Combustible Solids: Contamination present on combustible solids would not be readily entrained by the wind because the material was deposited several decades ago and the contaminants are expected to be absorbed onto the materials. It is expected that the amount of contamination released by this mechanism would be less than the amount released through a fire. Therefore, **the R value for entrainment is < 5E-04.**

Contaminated, Noncombustible Solids: Contamination present on noncombustible solids would not be readily entrained by the wind because the material was deposited several decades ago. It is expected that the amount of contamination released by this mechanism would be less than the amount released through dumping. Therefore, **the R value for entrainment is < 1E-03.**

Contaminated Liquid: Containerized liquid would be protected from entrainment by wind. If liquid is spilled, a small pool of liquid could form on the soil surface. Section 3.2.4.5 of DOE (2000) indicates that the bounding R value for entrainment from an outdoor pool at high windspeeds is 4E-6/hr, or 3.2E-05 for an 8-hr duration. [Note: An 8-hr exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.]. Therefore, **the R value for entrainment of contaminated liquid is 3.2E-05.**

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Spent Fuel Elements: No significant airborne release from spent fuel elements (metal) would occur due to high wind/entrainment, which is consistent with Section 4.2.4 of DOE (2000). This scenario is not considered further in this calculation. The airborne release of non-adherent uranium oxide from the surface of a spent fuel element via high wind/entrainment is expected to be less than that released by a drop/impact event. Therefore, **the R value for entrainment of the oxide is < 1E-03.**

6.3 Deflagration

Contaminated soil: The soil at the burial grounds is noncombustible. A fire burning across either site could entrain some of the soil in the updraft, but it would be expected that the amount released by this mechanism would be bounded by the amount of soil released through entrainment. Therefore, **the R value is 1.5E-08.**

Spent Fuel Elements (oxide): The spent fuel element material at risk during deflagration in the burial ground is limited to the pre-existent oxide. No significant airborne release of uranium metal is postulated, which is consistent with Section 4.2.2 of DOE (2000). The material release is conservatively evaluated as a venting of a pressurized powder at low pressures, consistent with the analysis performed for the 105-H facility (BHI 2003a). Only low pressures would be produced by this event due to the lack of confinement for the deflagration in an exposed excavation. The bounding airborne release fraction in Section 5.3.2.3 of DOE (2000) is 0.005, with a respirable fraction of 0.4 for low-pressure powders being vented. **This yields a bounding R value of 2.0E-03.**

Contaminated, Combustible Solids: Contaminated combustible solids (e.g., soft waste, used PPE) are expected to be present. Such materials are expected to have minimal contamination and do not provide a rigid surface for pressurized gases to act upon. DOE (2000), Section 5.2.2.3, states that the bounding **R value for this scenario is 1.0E-03**.

Contaminated, Noncombustible Solids: Contaminated noncombustible solids are expected to be present. Only those contaminated particles that are loose (i.e., not adhered tightly to the bulk solid) on the surface of the noncombustible solids would be subject to release. Section 5.3.2.3 of DOE (2000) indicates that **the bounding R value for the release of pressurized gases over contaminated, noncombustible materials is 2.0E-03.**

Contaminated liquid: The potential exists for containers of liquid to be unearthed during excavation activities. It is possible that a deflagration could occur during characterization activities that affects liquids. However, because the amount of flammable gases will be relatively small, the potential damage is expected to be low and localized. Section 3.2.2.3.2 of DOE (2000) indicates that **the bounding R value for a low-pressure deflagration venting of any solution would be 4.0E-05**.

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6.4 Dropping/Impact

Contaminated Soil: A vehicle or excavator impact to contaminated soil could result in resuspension of the material. However, only a small fraction of the potentially contaminated soil volume could be affected. Section 4.4.3.3.2 of DOE (2000) is not directly applicable to this scenario due to the physical differences between the experimental conditions (powder placed on a plywood sheet or in a quart can within a vented metal box) and the burial ground remediation activities (tens-of-thousands of kg of soil), but it does provide a reference point. The bounding R value in Section 4.4.3.3.2 of DOE (2000) is 2E-3. The outer areas of the large soil mass will shield the majority of the soil from impact stress, resulting in **a bounding R value much less than dumping of contaminated soils (<1.0E-06).**

Contaminated, Combustible Solids: Contaminated combustible solids may be lifted out of a trench and dropped. These combustible materials are typically lightweight. Consequently, they would generate little force during impact with surfaces. Section 5.2.3.2 of DOE (2000) states that solids that experience predominately plastic deformation (e.g. metal, plastics) as opposed to brittle fracture, respond to vibration and shock of the substrate by flexing. Materials adhering to the surface are ejected by the movement depending on how the contaminant is attached to the surface. The **bounding R value discussed in Section 5.3.3.2.2 is 1E-03**, therefore, this will be used for this scenario.

Contaminated, Noncombustible Solids: Contaminated, noncombustible solids may be lifted out of a trench and dropped, or digging equipment may impact them. DOE (2000), Section 5.3.3, addresses free-fall spill and impaction stress to such solids. The bounding ARF for shock-vibration of contaminated noncombustible materials that do not undergo brittle fracture is 1.0E-03. The respirable fraction is assumed to be 1.0; therefore, **the R value used for this scenario is 1.0E-03.**

Contaminated liquid: The potential exists for containers of liquid to be unearthed during excavation activities. It is possible that an impact to a container could occur during excavation activities. However, the amount of liquid would expected to be a small fraction of the total volume of the burial trenches. The bounding R value for this scenario would be less than that for a free-fall spill of aqueous solution. Therefore, **the R value is < 1E-04.**

Spent Fuel Elements: No significant airborne release from solid uranium metal would result from dropping of spent fuel elements, which is consistent with Section 4.2.3 of DOE (2000). Release of any oxide, however, would be similar to that from a contaminated, noncombustible solid. Therefore, **the R value used for this scenario for oxide is 1.0E-03.**

6.5 Fire

Contaminated soil: The soil at the burial grounds is noncombustible. A fire burning across either site could entrain some of the soil in the updraft, but it would be expected that the amount released by this mechanism would be bounded by the amount of soil released through entrainment. Therefore, **the R value is 1.5E-08.**

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6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms

Contaminated, Combustible Solids: This scenario would involve the ignition of soft waste by an external source such as a range fire or an internal source such as a vehicle fire. Contaminants remaining on soft waste would be well adhered after 30-60 years in the burial ground. Also, the soft waste is dispersed in a non-combustible (i.e., soil, metallic components) matrix and would be present as compact piles. **Therefore, the R value used for this scenario is 5.0E-04 as reported in Section 5.2.1.1 of DOE (2000) for packaged waste.**

Contaminated, Noncombustible Solids (including pre-existing oxide on spent fuel elements): A fire could suspend some of the surface contamination due to heating of the metallic components. DOE (2000), Section 5.1 (page 5-5) assesses the release of a sparse population of particles attached to the surface of a noncombustible solid. **The R value for this scenario is 6.0E-05.**

Contaminated liquid: A potential initiator of an on-site fire could be ignition of gasoline or diesel from the excavator. It is possible for containers to be heated by a fire and, as a result, the liquid contents could also be heated. Section 3.1 of DOE-HDBK-3010-94 (DOE 2000) indicates that the bounding values for boiling of aqueous solutions are an ARF of 2E-03 and an RF of 1.0, resulting in an **R value of 2E-3**.

Spent Fuel Elements (Oxide): This scenario is addressed under contaminated, non-combustible solids.

Spent Fuel Elements (metal): Section 4.1 of DOE-HDBK-3010-94 (DOE 2000) provides ARF and RF values for the oxidation of uranium metal at high temperatures (>500°C). The median ARF is 1E-4 and the RF is 1.0, resulting in an **R value of 1.0E-4**. These parameters are to be applied only to the oxide created during the fire and not to any un-oxidized portion of the uranium metal. The uranium that remains in metallic form is not at risk for release by thermal stress.

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6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms

6.6 Summary of Release Values Used in This Calculation

	Release Mechanism				
Material Form	**Dumping**	**Entrainment**	**Deflag-ration**	**Dropping/ Impact**	**Fire**
Soil	1.0E-06	1.5E-08	1.5E-08	1.0E-06	1.5E-08
Combustibles	Insignificant	5.0E-04	1.0E-03	1.0E-03	5.0E-04
Noncombustibles	1.0E-03	1.0E-03	2.0E-03	1.0E-03	6.0E-05
Liquid	1.0E-04	3.2E-05	4.0E-05	1.0E-04	2.0E-03
Spent Fuel Element (Oxide)	1.0E-03	1.0E-03	2.0E-03	1.0E-03	6.0E-05
Spent Fuel Element (Metal)	Insignificant	Insignificant	Insignificant	Insignificant	1.0E-04

Evaluation of the release values in the above table shows that no significant release from the spent fuel element (metal) is postulated except for a fire.

7.0 Adjustments to Material Inventories

7.1 Liquids

Conservatively, the entire liquid inventory is considered to be at risk for all hazard scenarios.

7.2 Contaminated Soil

A fractional amount of the activity from general radioactive waste was qualified as a noncombustible dispersible solid in the form of a powder.

For purposes of soil removal during high winds Sehmel (1980) provides a bounding depth of 10 mm for soil at risk for resuspension by high wind. A typical trench depth is 4600 mm, so a high wind event would impact 10/4600 or 0.2%. The amount of soil considered to be available for entrainment due to a high wind event is conservatively assumed to be 10%.

The amount of contaminated soil considered to be available for damage during a fire is conservatively taken to be 100%.

For the deflagration, dumping/spilling, and dropping/impact hazards, only a small fraction of the noncombustible solid inventory would be expected to be involved in the hazard. The fraction of contaminated soil at risk in these hazards is taken to be 1% of the total soil inventory. This percentage is conservative and bounding based on the assumption that a 25 mm deep layer of a single trench is less than 1% of the total volume. A deflagration, dump, spill, drop, or impact event would occur within a much more localized volume or surface area; therefore, the 1% value is bounding and conservative.

7.3 Uranium Metal Solids

The spent fuel elements are encased in cladding, though 20% of the fuel elements are assumed to be damaged and breached. Experience at other excavation sites has shown that multiple fuel elements have not been unearthed in the same excavator bucket load.

For the fire hazard event, the ARF and RF values should be applied only to oxide created during a fire and not to any un-oxidized metal. As discussed in Section 4.2.1.2 of DOE-HDBK-3010-94 (DOE 2000), oxidation of uranium under fire conditions does take place. However, not all of the uranium in the spent fuel is expected to oxidize.

The bounding fire at a burial ground from the standpoint of uranium metal oxidation would be a pool fire involving diesel fuel spilled from a piece of large equipment (e.g., excavator) or from a refueling truck. (Note that other scenarios are bounding for the purpose of deriving other values, such as the percentage of waste impacted by a fire.) The scenario would involve a spill of diesel onto the soil surface of the burial ground such that a pool is formed. The pool is then ignited and burns until the fuel is exhausted. Some fraction of the spilled diesel would be absorbed by the soil, which would serve to reduce the amount of fuel available to burn and, consequently, the duration of the fire. The burning rate of diesel is in the range of 5 to 8 in. (13 to 20 cm) of depth per hour (NFPA 1991).

Given (1) the burning rate of diesel, (2) the absorption of some fraction of the spilled diesel by the soil, (3) the burial ground terrain and (4) the potential volume of a diesel spill (100-200 gal.), a reasonably conservative maximum duration for a diesel fuel pool fire at a burial ground is estimated to be 30 minutes (i.e., 2.5 to 4 in. of pool depth burned). It is expected that the continuous flame region temperature for a diesel fuel pool fire at a burial ground would range from 900 °C to 1100 °C. This is consistent with the analysis made for the 118-B-1/118-C-1 burial grounds (BHI 2005d).

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7.3 Uranium Metal Solids (continued)

The "Basis for Interim Operation for Fuel Supply Shutdown Facility" (Benecke 2003) evaluates the oxidation of uranium metal fuel in a storage building fire. An 8-hr fire duration, including 2.5 hours at or above 1000 °C, is used to determine the fraction of the uranium metal oxidized. The evaluation determined that 5% of the uranium metal would be oxidized in such a fire event.

An investigation titled "Oxidation of Uranium in Air at High Temperatures" (GE 1958) examined the oxidation of small (1/4 to 1/2 inch in diameter by 3/4 to 1 inch in length) pieces of metallic uranium at temperatures ranging from 300°C to 1440 °C. The cylindrical test specimens were prepared by swaging from a Hanford reactor fuel element. Oxidation rate equations for uranium metal as a function of the area to weight ratio of the cylindrical specimens were determined. Using an area to weight ratio of 0.08 cm^2/g for a typical uranium metal fuel element (i.e., $260cm^2/3{,}200g$), oxidation rates of about 15.5 mg U/cm^2-min and 34.3 mg U/cm^2-min are predicted at 995 °C and 1200 °C by solving the appropriate oxidation rate equations in (GE 1958). This would imply that 121 g to 267 g, or 3.8% to 8.3% of the mass of uranium metal in a typical fuel element would be oxidized in 30 minutes.

Section 4.2.1.2.1 of DOE-HDBK-3010-94 (DOE 2000) discusses oxidation at elevated temperatures in a fire. A study by Elder and Tinkle is cited that involved 13 experiments, performed from 500°C to 1000 °C for durations of 2 or 4 hours. The oxidation of the uranium ranged from 6.2% to 22.1% for the 2-hour fires (1.6 % to 5.5% per 30 minutes) and from 21.3% to 30.2% for the 4-hour fires (2.7% to 3.8% per 30 minutes).

Because the burial ground fire is estimated to burn for 30 minutes, a value of 10% is chosen to represent the amount of uranium metal that oxidizes during the fire hazard scenario. This value bounds the each of the references cited above.

7.4 Non-combustible Solids

The noncombustible solids are comprised of metal reactor waste with surface contamination. In general, only those contaminated particles that are loose (i.e., not combined with the surface matrix) on the surface of the noncombustible solids are subject to release. The material at risk is therefore reduced.

It is assumed that 90% of the radionuclide inventory associated with the non-combustable solids inventory is activation products within the solid material and 10% is contamination on the surface of the solid material. For the entrainment / high wind and fire hazards, only those portions of the noncombustible solid inventory that are loose are susceptible to the hazard (according to Section 5.1 of DOE-HDBK-3010-94 [DOE 2000], the ARF and RF values for these two hazards are to be applied only to loose surface contamination and not to radionuclides integral to the bulk solid). The fraction of solid noncombustible material at risk in these hazards is taken to be 10% (percent of material that is loose contamination) of the total solid

For the deflagration, dumping / spilling, and dropping / impact hazards, only a small fraction of the noncombustible solid inventory is expected to be involved in the hazard. The fraction of solid noncombustible material at risk in these hazards is taken to be 1% of the total solid noncombustible inventory. The basis for the 1% value is similar to that explained in the final paragraph (deflagration, dumping/spilling, and dropping/impact hazards) of Section 7.2.

7.5 Combustible Solids

A portion of the general radioactive waste is treated as combustible solids. The fraction of combustible solids available for damage during the hazard event of entrainment / high wind is taken to be 10% of the total combustible solid inventory. A 10% material availability for damage was selected as a conservative upper bound based on the fact that combustible solids are generally packaged in boxes, drums, etc and are, therefore, afforded a certain self-protection against high winds. Additionally, it would be necessary for the material to be exposed to the winds by the excavation process. It is not credible to assume that the excavator would exhume more than 10% of the radioactive inventory at any given time and leave it exposed for entrainment by high winds.

For the fire hazard, only a portion of the combustible solid inventory in the waste site is at risk (it is unlikely that a fire consumes all the un-excavated waste). Nevertheless, the fraction of solid combustible material at risk in this hazard is conservatively taken to be 100% of the total solid combustible inventory.

For the deflagration, dumping / spilling, and dropping / impact hazards, only a small fraction of the combustible solid inventory is expected to be involved in the hazard. The fraction of solid combustible material at risk in these hazards is taken to be 1% of the total solid combustible inventory. The basis for the 1% value is similar to that explained in the final paragraph (deflagration, dumping/spilling, and dropping/impact hazards) of Section 7.2.

7.6 Uranium Oxide

As discussed in Section 4, "Assumptions", 0.1% of the total uranium fuel inventory is assumed to be uranium oxide. The thin layer of oxide is only present when the cladding has been breached. It is assumed that 100% of this inventory for all accdients is considered available for release.

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7.7 Summary of Adjustments to Material Inventory

The fraction of each waste form subject to damage from a given hazard (determined in the preceding subsections) is summarized in the table below.

Material Form	Percent of Total Inventory Subject to Hazard				
	Entrainment / High Wind	Fire	Deflagration	Dumping / Spilling	Dropping/ Impact
Liquids	100%	100%	100%	100%	100%
Soil	10%	100%	1%	1%	1%
U Metal	20%	10%	20%	5%	5%
Noncombustible	10%	10%	1%	1%	1%
Combustible	10%	100%	1%	1%	1%
U Oxide	100%	100%	100%	100%	100%

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Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky TJR Date: 11/7/06 Calc. No.: 0100X-CA-N0020 Rev. No.: 1
Project: D/DR/H Field Remediation Job No.: 14655 Checked: J. D. Ludowise JDL Date: 11-7-06
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs) Sheet No.: 16 of 38

7.8 Radionuclide Inventory - (For the Bounding 118-D-3 Site)

Isotope	Radionuclide Inventory (Ci) [2]	Combustible Inventory (Ci)[3]	Non-combustible Inventory (Ci)[4]	Soil Inventory (Ci)[5]	Liquid Inventory (Ci)[6]	Spent Fuel Element Inventory (25 Fuel Elements)	
						Total (Ci)[2]	0.1% Oxide (Ci)[1]
Ag-108m	9.59E+00	4.80E-01	7.66E+00	1.35E+00	9.59E-02		
Am-241	1.02E+00	5.09E-02	8.13E-01	1.43E-01	1.02E-02	2.96E+00	2.96E-03
Ba-133	1.44E-01	7.20E-03	1.15E-01	2.03E-02	1.44E-03		
C-14	1.01E+00	5.05E-02	8.07E-01	1.42E-01	1.01E-02		
Ca-41	1.00E-02	5.00E-04	7.99E-03	1.41E-03	1.00E-04		
Cd-113m						3.87E-03	3.87E-06
Co-60	3.23E+01	1.61E+00	2.58E+01	4.55E+00	3.23E-01		
Cs-137	1.33E+02	6.66E+00	1.06E+02	1.88E+01	1.33E+00	1.26E+02	1.26E-01
Eu-152	8.69E-01	4.34E-02	6.94E-01	1.22E-01	8.69E-03	5.33E-04	5.33E-07
Eu-154	3.02E-01	1.51E-02	2.42E-01	4.27E-02	3.02E-03		
Eu-155	1.33E-01	6.65E-03	1.06E-01	1.87E-02	1.33E-03		
H-3	1.93E+02	9.64E+00	1.54E+02	2.72E+01	1.93E+00		
Kr-85	4.77E+00	2.38E-01	3.81E+00	6.72E-01	4.77E-02	2.74E+00	2.74E-03
Nb-94	3.21E-02	1.60E-03	2.56E-02	4.52E-03	3.21E-04	4.00E-03	4.00E-06
Ni-59	6.14E+00	3.07E-01	4.91E+00	8.66E-01	6.14E-02		
Ni-63	2.29E+02	1.15E+01	1.83E+02	3.23E+01	2.29E+00		
Pd-107						1.00E-04	1.00E-07
Pu-238	5.22E-02	2.61E-03	4.17E-02	7.37E-03	5.22E-04	8.54E-02	8.54E-05
Pu-239	6.32E-02	3.16E-03	5.05E-02	8.92E-03	6.32E-04	6.00E+00	6.00E-03
Pu-240						1.50E+00	1.50E-03
Pu-241						1.95E+01	1.95E-02
Se-79	5.59E-01	2.80E-02	4.47E-01	7.88E-02	5.59E-03	1.00E-03	1.00E-06
Sm-151						1.71E+00	1.71E-03
Sr-90	1.41E+00	7.07E-02	1.13E+00	1.99E-01	1.41E-02	1.24E+02	1.24E-01
Tc-99	9.99E-02	4.99E-03	7.98E-02	1.41E-02	9.99E-04	5.00E+00	5.00E-03
U-235	7.51E-02	3.76E-03	6.00E-02	1.06E-02	7.51E-04		
U-238	7.66E-02	3.83E-03	6.12E-02	1.08E-02	7.66E-04	3.00E-02	3.00E-05
Zr-93						1.00E-02	1.00E-05

(1) Oxide inventory determined by assuming that 0.1% of the total inventory is in the form of oxide.

(2) Data from WCH 2006b and WCH 2006a.

(3) Assumes 5% of the burial ground inventory is combustible (i.e., soft waste). This is consistent with the FHC calculation for the 118-K-1 Burial Ground (WCH 2006c) and the 100-B/C Burial Grounds (BHI 2005c).

(4) Contaminated, noncombustible solids inventory was calculated by subtracting the total combustible and liquid inventories from the total inventory and multiplying by 85%.

(5) Particulate inventory was calculated by subtracting the combustible and liquid inventories from the total inventory and multiplying by 15%.

(6) Liquid inventory is assumed to be 1% of the total inventory.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc (16) (Inventory)

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Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs) **Sheet No.:** 17 of 38

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9.0 Calculation of Revised TQ Values

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA}[(1)]	RV_{HA}	Food[(2)] Ingestion RV (Ci)	Adjusted[(3)] Food Ingestion RV (Ci)	Water[(4)] Ingestion RV (Ci)	Inhalation RV[(5)] (Ci)	Adjusted[(3)] Inhalation RV (Ci)	Direct[(6)] Exposure RV (Ci)	$TQ_{REVISED}$[(7)] (Ci)
SOIL – DEFLAGRATION, ENTRAINMENT AND FIRE									
Ag-108m	1.0E-02	1.5E-08	1.8E+01	1.2E+07	v. lg.	1.0E+01	6.7E+06	2.2E+01	4.4E+02
Am-241	1.0E-03	1.5E-08	3.0E-01	2.0E+04	v. lg.	2.6E-02	1.7E+03	--	3.5E+04
Ba-133	1.0E-02	1.5E-08	5.9E+01	3.9E+07	v. lg.	3.6E+02	2.4E+08	1.0E+02	2.0E+03
C-14	5.0E-01	1.5E-08	--	--	1.5E+02	2.1E+01	7.0E+08	--	3.0E+03
Ca-41	1.0E-02	1.5E-08	8.0E+01	5.3E+07	v. lg.	2.1E+03	1.4E+09	--	1.1E+09
Cd-113	1.0E-02	1.5E-08	5.8E-01	3.9E+05	v. lg.	1.0E+00	6.7E+05	--	7.7E+06
Co-60[(8)]	1.0E-03	1.5E-08	6.0E+01	4.0E+06	v. lg.	1.6E+02	1.1E+07	1.5E+01	2.8E+02
Cs-137	1.0E-02	1.5E-08	3.0E+00	2.0E+06	v. lg.	1.0E+02	6.7E+07	6.5E+01	1.3E+03
Eu-152	1.0E-02	1.5E-08	2.4E+01	1.6E+07	v. lg.	1.0E+01	6.7E+06	3.5E+01	7.0E+02
Eu-154	1.0E-02	1.5E-08	1.5E+01	1.0E+07	v. lg.	1.0E+01	6.7E+06	4.2E+01	8.4E+02
Eu-155	1.0E-02	1.5E-08	1.2E+02	8.0E+07	v. lg.	4.7E+01	3.1E+07	7.0E+02	1.4E+04
H-3	5.0E-01	1.5E-08	--	--	5.9E+03	8.3E+02	2.8E+10	--	1.2E+05
Kr-85	1.0E+00	1.5E-08	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	1.5E-08	2.7E+01	1.8E+07	v. lg.	1.0E+01	6.7E+06	2.3E+01	4.6E+02
Ni-59	1.0E-02	1.5E-08	5.9E+02	3.9E+08	v. lg.	2.1E+03	1.4E+09	--	7.9E+09
Ni-63	1.0E-02	1.5E-08	2.7E+02	1.8E+08	v. lg.	1.0E+03	6.7E+08	--	3.6E+09
Pd-107	1.0E-02	1.5E-08	8.9E+02	5.9E+08	v. lg.	2.1E+02	1.4E+08	--	2.8E+09
Pu-238	1.0E-03	1.5E-08	2.1E+00	1.4E+05	v. lg.	3.1E-02	2.1E+03	--	4.1E+04
Pu-239	1.0E-03	1.5E-08	1.8E+00	1.2E+05	v. lg.	2.6E-02	1.7E+03	1.7E+06	3.5E+04
Pu-240	1.0E-03	1.5E-08	1.8E+00	1.2E+05	v. lg.	2.6E-02	1.7E+03	5.0E+06	3.5E+04
Pu-241	1.0E-03	1.5E-08	9.0E+01	6.0E+06	v. lg.	1.6E+00	1.1E+05	1.4E+08	2.1E+06
Se-79	1.0E-02	1.5E-08	1.8E+01	1.2E+07	v. lg.	3.1E+02	2.1E+08	--	2.4E+08
Sm-151	1.0E-02	1.5E-08	3.0E+02	2.0E+08	v. lg.	5.2E+01	3.5E+07	--	6.9E+08
Sr-90	1.0E-02	1.5E-08	8.2E-01	5.5E+05	v. lg.	2.1E+00	1.4E+06	--	1.1E+07
Tc-99	1.0E-02	1.5E-08	8.9E+01	5.9E+07	2.9E+02	3.6E+02	2.4E+08	--	5.8E+03
U-235	1.0E-03	1.5E-08	3.0E+00	2.0E+05	v. lg.	2.1E-01	1.4E+04	2.7E+02	5.4E+03
U-238	1.0E-03	1.5E-08	3.0E+00	2.0E+05	v. lg.	2.1E-01	1.4E+04	--	2.8E+05
Zr-93	1.0E-02	1.5E-08	3.0E+01	2.0E+07	v. lg.	3.1E+00	2.1E+06	--	4.1E+07

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides". EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/O = 0.072\ m^3/sec$).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$) and average breathing rate ($2.7E-4\ m^3/sec$).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

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9.0 Calculation of Revised TQ Values

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
LIQUID – FIRE									
SPENT FUEL ELEMENTS (OXIDE) & NONCOMBUSTABLE MATERIAL – DEFLAGRATION									
Ag-108m	1.0E-02	2.0E-03	1.8E+01	9.0E+01	v. lg.	1.0E+01	5.0E+01	2.2E+01	4.4E+02
Am-241	1.0E-03	2.0E-03	3.0E-01	1.5E-01	v. lg.	2.6E-02	1.3E-02	--	2.6E-01
Ba-133	1.0E-02	2.0E-03	5.9E+01	3.0E+02	v. lg.	3.6E+02	1.8E+03	1.0E+02	2.0E+03
C-14	5.0E-01	2.0E-03	--	--	1.5E+02	2.1E+01	5.3E+03	--	3.0E+03
Ca-41	1.0E-02	2.0E-03	8.0E+01	4.0E+02	v. lg.	2.1E+03	1.1E+04	--	8.0E+03
Cd-113	1.0E-02	2.0E-03	5.8E-01	2.9E+00	v. lg.	1.0E+00	5.0E+00	--	5.8E+01
Co-60(8)	1.0E-03	2.0E-03	6.0E+01	3.0E+01	v. lg.	1.6E+02	8.0E+01	1.5E+01	2.8E+02
Cs-137	1.0E-02	2.0E-03	3.0E+00	1.5E+01	v. lg.	1.0E+02	5.0E+02	6.5E+01	3.0E+02
Eu-152	1.0E-02	2.0E-03	2.4E+01	1.2E+02	v. lg.	1.0E+01	5.0E+01	3.5E+01	7.0E+02
Eu-154	1.0E-02	2.0E-03	1.5E+01	7.5E+01	v. lg.	1.0E+01	5.0E+01	4.2E+01	8.4E+02
Eu-155	1.0E-02	2.0E-03	1.2E+02	6.0E+02	v. lg.	4.7E+01	2.4E+02	7.0E+02	4.7E+03
H-3	5.0E-01	2.0E-03	--	--	5.9E+03	8.3E+02	2.1E+05	--	1.2E+05
Kr-85	1.0E+00	2.0E-03	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	2.0E-03	2.7E+01	1.4E+02	v. lg.	1.0E+01	5.0E+01	2.3E+01	4.6E+02
Ni-59	1.0E-02	2.0E-03	5.9E+02	3.0E+03	v. lg.	2.1E+03	1.1E+04	--	5.9E+04
Ni-63	1.0E-02	2.0E-03	2.7E+02	1.4E+03	v. lg.	1.0E+03	5.0E+03	--	2.7E+04
Pd-107	1.0E-02	2.0E-03	8.9E+02	4.5E+03	v. lg.	2.1E+02	1.1E+03	--	2.1E+04
Pu-238	1.0E-03	2.0E-03	2.1E+00	1.1E+00	v. lg.	3.1E-02	1.6E-02	--	3.1E-01
Pu-239	1.0E-03	2.0E-03	1.8E+00	9.0E-01	v. lg.	2.6E-02	1.3E-02	1.7E+06	2.6E-01
Pu-240	1.0E-03	2.0E-03	1.8E+00	9.0E-01	v. lg.	2.6E-02	1.3E-02	5.0E+06	2.6E-01
Pu-241	1.0E-03	2.0E-03	9.0E+01	4.5E+01	v. lg.	1.6E+00	8.0E-01	1.4E+08	1.6E+01
Se-79	1.0E-02	2.0E-03	1.8E+01	9.0E+01	v. lg.	3.1E+02	1.6E+03	--	1.8E+03
Sm-151	1.0E-02	2.0E-03	3.0E+02	1.5E+03	v. lg.	5.2E+01	2.6E+02	--	5.2E+03
Sr-90	1.0E-02	2.0E-03	8.2E-01	4.1E+00	v. lg.	2.1E+00	1.1E+01	--	8.2E+01
Tc-99	1.0E-02	2.0E-03	8.9E+01	4.5E+02	2.9E+02	3.6E+02	1.8E+03	--	5.8E+03
U-235	1.0E-03	2.0E-03	3.0E+00	1.5E+00	v. lg.	2.1E-01	1.1E-01	--	2.1E+00
U-238	1.0E-03	2.0E-03	3.0E+00	1.5E+00	v. lg.	2.1E-01	1.1E-01	--	2.1E+00
Zr-93	1.0E-02	2.0E-03	3.0E+01	1.5E+02	v. lg.	3.1E+00	1.6E+01	--	3.1E+02

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$) and average breathing rate ($2.7E\text{-}4\ m^3/sec$).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TJL	**Date:**	11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:** 1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:** J. D. Ludowise JL	**Date:** 11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)				**Sheet No.:** 21 of 38

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
SPENT FUEL ELEMENTS (OXIDE) & NONCOMBUSTABLE MATERIAL – FIRE									
Ag-108m	1.0E-02	6.0E-05	1.8E+01	3.0E+03	v. lg.	1.0E+01	1.7E+03	2.2E+01	4.4E+02
Am-241	1.0E-03	6.0E-05	3.0E-01	5.0E+00	v. lg.	2.6E-02	4.3E-01	--	8.7E+00
Ba-133	1.0E-02	6.0E-05	5.9E+01	9.8E+03	v. lg.	3.6E+02	6.0E+04	1.0E+02	2.0E+03
C-14	5.0E-01	6.0E-05	--	--	1.5E+02	2.1E+01	1.8E+05	--	3.0E+03
Ca-41	1.0E-02	6.0E-05	8.0E+01	1.3E+04	v. lg.	2.1E+03	3.5E+05	--	2.7E+05
Cd-113	1.0E-02	6.0E-05	5.8E-01	9.7E+01	v. lg.	1.0E+00	1.7E+02	--	1.9E+03
Co-60(8)	1.0E-03	6.0E-05	6.0E+01	1.0E+03	v. lg.	1.6E+02	2.7E+03	1.5E+01	2.8E+02
Cs-137	1.0E-02	6.0E-05	3.0E+00	5.0E+02	v. lg.	1.0E+02	1.7E+04	6.5E+01	1.3E+03
Eu-152	1.0E-02	6.0E-05	2.4E+01	4.0E+03	v. lg.	1.0E+01	1.7E+03	3.5E+01	7.0E+02
Eu-154	1.0E-02	6.0E-05	1.5E+01	2.5E+03	v. lg.	1.0E+01	1.7E+03	4.2E+01	8.4E+02
Eu-155	1.0E-02	6.0E-05	1.2E+02	2.0E+04	v. lg.	4.7E+01	7.8E+03	7.0E+02	1.4E+04
H-3	5.0E-01	6.0E-05	--	--	5.9E+03	8.3E+02	6.9E+06	--	1.2E+05
Kr-85	1.0E+00	6.0E-05	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	6.0E-05	2.7E+01	4.5E+03	v. lg.	1.0E+01	1.7E+03	2.3E+01	4.6E+02
Ni-59	1.0E-02	6.0E-05	5.9E+02	9.8E+04	v. lg.	2.1E+03	3.5E+05	--	2.0E+06
Ni-63	1.0E-02	6.0E-05	2.7E+02	4.5E+04	v. lg.	1.0E+03	1.7E+05	--	9.0E+05
Pd-107	1.0E-02	6.0E-05	8.9E+02	1.5E+05	v. lg.	2.1E+02	3.5E+04	--	7.0E+05
Pu-238	1.0E-03	6.0E-05	2.1E+00	3.5E+01	v. lg.	3.1E-02	5.2E-01	--	1.0E+01
Pu-239	1.0E-03	6.0E-05	1.8E+00	3.0E+01	v. lg.	2.6E-02	4.3E-01	1.7E+06	8.7E+00
Pu-240	1.0E-03	6.0E-05	1.8E+00	3.0E+01	v. lg.	2.6E-02	4.3E-01	5.0E+06	8.7E+00
Pu-241	1.0E-03	6.0E-05	9.0E+01	1.5E+03	v. lg.	1.6E+00	2.7E+01	1.4E+08	5.3E+02
Se-79	1.0E-02	6.0E-05	1.8E+01	3.0E+03	v. lg.	3.1E+02	5.2E+04	--	6.0E+04
Sm-151	1.0E-02	6.0E-05	3.0E+02	5.0E+04	v. lg.	5.2E+01	8.7E+03	--	1.7E+05
Sr-90	1.0E-02	6.0E-05	8.2E-01	1.4E+02	v. lg.	2.1E+00	3.5E+02	--	2.7E+03
Tc-99	1.0E-02	6.0E-05	8.9E+01	1.5E+04	2.9E+02	3.6E+02	6.0E+04	--	5.8E+03
U-235	1.0E-03	6.0E-05	3.0E+00	5.0E+01	v. lg.	2.1E-01	3.5E+00	--	7.0E+01
U-238	1.0E-03	6.0E-05	3.0E+00	5.0E+01	v. lg.	2.1E-01	3.5E+00	--	7.0E+01
Zr-93	1.0E-02	6.0E-05	3.0E+01	5.0E+03	v. lg.	3.1E+00	5.2E+02	--	1.0E+04

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/O = 0.072\ m^3/sec$).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$) and average breathing rate ($2.7E\text{-}4\ m^3/sec$).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TL	Date: 11/7/06	Calc. No.: 0100X-CA-N0020	Rev. No.:	1
Project:	D/DR/H Field Remediation	Job No.: 14655	Checked: J. D. Ludowise JK	Date:	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			Sheet No.:	22 of 38

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
LIQUID – DUMPING & DROPPING/IMPACT									
SPENT FUEL ELEMENTS (METAL) – FIRE									
Ag-108m	1.0E-02	1.0E-04	1.8E+01	1.8E+03	v. lg.	1.0E+01	1.0E+03	2.2E+01	4.4E+02
Am-241	1.0E-03	1.0E-04	3.0E-01	3.0E+00	v. lg.	2.6E-02	2.6E-01	--	5.2E+00
Ba-133	1.0E-02	1.0E-04	5.9E+01	5.9E+03	v. lg.	3.6E+02	3.6E+04	1.0E+02	2.0E+03
C-14	5.0E-01	1.0E-04	--	--	1.5E+02	2.1E+01	1.1E+05	--	3.0E+03
Ca-41	1.0E-02	1.0E-04	8.0E+01	8.0E+03	v. lg.	2.1E+03	2.1E+05	--	1.6E+05
Cd-113	1.0E-02	1.0E-04	5.8E-01	5.8E+01	v. lg.	1.0E+00	1.0E+02	--	1.2E+03
Co-60(8)	1.0E-03	1.0E-04	6.0E+01	6.0E+02	v. lg.	1.6E+02	1.6E+03	1.5E+01	2.8E+02
Cs-137	1.0E-02	1.0E-04	3.0E+00	3.0E+02	v. lg.	1.0E+02	1.0E+04	6.5E+01	1.3E+03
Eu-152	1.0E-02	1.0E-04	2.4E+01	2.4E+03	v. lg.	1.0E+01	1.0E+03	3.5E+01	7.0E+02
Eu-154	1.0E-02	1.0E-04	1.5E+01	1.5E+03	v. lg.	1.0E+01	1.0E+03	4.2E+01	8.4E+02
Eu-155	1.0E-02	1.0E-04	1.2E+02	1.2E+04	v. lg.	4.7E+01	4.7E+03	7.0E+02	1.4E+04
H-3	5.0E-01	1.0E-04	--	--	5.9E+03	8.3E+02	4.2E+06	--	1.2E+05
Kr-85	1.0E+00	1.0E-04	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	1.0E-04	2.7E+01	2.7E+03	v. lg.	1.0E+01	1.0E+03	2.3E+01	4.6E+02
Ni-59	1.0E-02	1.0E-04	5.9E+02	5.9E+04	v. lg.	2.1E+03	2.1E+05	--	1.2E+06
Ni-63	1.0E-02	1.0E-04	2.7E+02	2.7E+04	v. lg.	1.0E+03	1.0E+05	--	5.4E+05
Pd-107	1.0E-02	1.0E-04	8.9E+02	8.9E+04	v. lg.	2.1E+02	2.1E+04	--	4.2E+05
Pu-238	1.0E-03	1.0E-04	2.1E+00	2.1E+01	v. lg.	3.1E-02	3.1E-01	--	6.2E+00
Pu-239	1.0E-03	1.0E-04	1.8E+00	1.8E+01	v. lg.	2.6E-02	2.6E-01	1.7E+06	5.2E+00
Pu-240	1.0E-03	1.0E-04	1.8E+00	1.8E+01	v. lg.	2.6E-02	2.6E-01	5.0E+06	5.2E+00
Pu-241	1.0E-03	1.0E-04	9.0E+01	9.0E+02	v. lg.	1.6E+00	1.6E+01	1.4E+08	3.2E+02
Se-79	1.0E-02	1.0E-04	1.8E+01	1.8E+03	v. lg.	3.1E+02	3.1E+04	--	3.6E+04
Sm-151	1.0E-02	1.0E-04	3.0E+02	3.0E+04	v. lg.	5.2E+01	5.2E+03	--	1.0E+05
Sr-90	1.0E-02	1.0E-04	8.2E-01	8.2E+01	v. lg.	2.1E+00	2.1E+02	--	1.6E+03
Tc-99	1.0E-02	1.0E-04	8.9E+01	8.9E+03	2.9E+02	3.6E+02	3.6E+04	--	5.8E+03
U-235	1.0E-03	1.0E-04	3.0E+00	3.0E+01	v. lg.	2.1E-01	2.1E+00	2.7E+02	4.2E+01
U-238	1.0E-03	1.0E-04	3.0E+00	3.0E+01	v. lg.	2.1E-01	2.1E+00	--	4.2E+01
Zr-93	1.0E-02	1.0E-04	3.0E+01	3.0E+03	v. lg.	3.1E+00	3.1E+02	--	6.2E+03

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$) and average breathing rate ($2.7E\text{-}4\ m^3/sec$).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TJR	**Date:** 11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:** 14655	**Checked:** J. D. Ludowise JDL	**Date:**	11-2-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			**Sheet No.:**	23 of 38

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
COMBUSTIBLE MATERIALS – ENTRAINMENT AND FIRE									
Ag-108m	1.0E-02	5.0E-04	1.8E+01	3.6E+02	v. lg.	1.0E+01	2.0E+02	2.2E+01	4.4E+02
Am-241	1.0E-03	5.0E-04	3.0E-01	6.0E-01	v. lg.	2.6E-02	5.2E-02	--	1.0E+00
Ba-133	1.0E-02	5.0E-04	5.9E+01	1.2E+03	v. lg.	3.6E+02	7.2E+03	1.0E+02	2.0E+03
C-14	5.0E-01	5.0E-04	--	--	1.5E+02	2.1E+01	2.1E+04	--	3.0E+03
Ca-41	1.0E-02	5.0E-04	8.0E+01	1.6E+03	v. lg.	2.1E+03	4.2E+04	--	3.2E+04
Cd-113	1.0E-02	5.0E-04	5.8E-01	1.2E+01	v. lg.	1.0E+00	2.0E+01	--	2.3E+02
Co-60(8)	1.0E-03	5.0E-04	6.0E+01	1.2E+02	v. lg.	1.6E+02	3.2E+02	1.5E+01	2.8E+02
Cs-137	1.0E-02	5.0E-04	3.0E+00	6.0E+01	v. lg.	1.0E+02	2.0E+03	6.5E+01	1.2E+03
Eu-152	1.0E-02	5.0E-04	2.4E+01	4.8E+02	v. lg.	1.0E+01	2.0E+02	3.5E+01	7.0E+02
Eu-154	1.0E-02	5.0E-04	1.5E+01	3.0E+02	v. lg.	1.0E+01	2.0E+02	4.2E+01	8.4E+02
Eu-155	1.0E-02	5.0E-04	1.2E+02	2.4E+03	v. lg.	4.7E+01	9.4E+02	7.0E+02	1.4E+04
H-3	5.0E-01	5.0E-04	--	--	5.9E+03	8.3E+02	8.3E+05	--	1.2E+05
Kr-85	1.0E+00	5.0E-04	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	5.0E-04	2.7E+01	5.4E+02	v. lg.	1.0E+01	2.0E+02	2.3E+01	4.6E+02
Ni-59	1.0E-02	5.0E-04	5.9E+02	1.2E+04	v. lg.	2.1E+03	4.2E+04	--	2.4E+05
Ni-63	1.0E-02	5.0E-04	2.7E+02	5.4E+03	v. lg.	1.0E+03	2.0E+04	--	1.1E+05
Pd-107	1.0E-02	5.0E-04	8.9E+02	1.8E+04	v. lg.	2.1E+02	4.2E+03	--	8.4E+04
Pu-238	1.0E-03	5.0E-04	2.1E+00	4.2E+00	v. lg.	3.1E-02	6.2E-02	--	1.2E+00
Pu-239	1.0E-03	5.0E-04	1.8E+00	3.6E+00	v. lg.	2.6E-02	5.2E-02	1.7E+06	1.0E+00
Pu-240	1.0E-03	5.0E-04	1.8E+00	3.6E+00	v. lg.	2.6E-02	5.2E-02	5.0E+06	1.0E+00
Pu-241	1.0E-03	5.0E-04	9.0E+01	1.8E+02	v. lg.	1.6E+00	3.2E+00	1.4E+08	6.4E+01
Se-79	1.0E-02	5.0E-04	1.8E+01	3.6E+02	v. lg.	3.1E+02	6.2E+03	--	7.2E+03
Sm-151	1.0E-02	5.0E-04	3.0E+02	6.0E+03	v. lg.	5.2E+01	1.0E+03	--	2.1E+04
Sr-90	1.0E-02	5.0E-04	8.2E-01	1.6E+01	v. lg.	2.1E+00	4.2E+01	--	3.3E+02
Tc-99	1.0E-02	5.0E-04	8.9E+01	1.8E+03	2.9E+02	3.6E+02	7.2E+03	--	5.8E+03
U-235	1.0E-03	5.0E-04	3.0E+00	6.0E+00	v. lg.	2.1E-01	4.2E-01	2.7E+02	8.4E+00
U-238	1.0E-03	5.0E-04	3.0E+00	6.0E+00	v. lg.	2.1E-01	4.2E-01	--	8.4E+00
Zr-93	1.0E-02	5.0E-04	3.0E+01	6.0E+02	v. lg.	3.1E+00	6.2E+01	--	1.2E+03

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response. Compensation, and Liability Act: Radionuclides". EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072\ m^3/sec$) and average breathing rate ($2.7E-4\ m^3/sec$).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc(23) Rev TQ (5E-4)

Washington Closure Hanford, LLC.

Orig T.J. Rodovsky TJR Date: 11/7/06 Calc. No.: 0100X-CA-N0020 Rev. No.: 1
Proj D/DR/H Field Remediation Job No.: 14655 Checked: J.D. Ludowise JDL Date: 11-7-06
Sub 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Sheet No.: 24 of 38
Categorization Calculation (Revised TQs)

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
SPENT FUEL OXIDE – DUMPING, ENTRAINMENT, DROPPING/IMPACT									
NON-COMBUSTABLES – DUMPING, ENTRAINMENT, DROPPING/IMPACT									
COMBUSTIBLE MATERIALS – DEFLAGRATION & DROPPING/IMPACT									
Ag-108m	1.0E-02	1.0E-03	1.8E+01	1.8E+02	v. lg.	1.0E+01	1.0E+02	2.2E+01	4.4E+02
Am-241	1.0E-03	1.0E-03	3.0E-01	3.0E-01	v. lg.	2.6E-02	2.6E-02	--	5.2E-01
Ba-133	1.0E-02	1.0E-03	5.9E+01	5.9E+02	v. lg.	3.6E+02	3.6E+03	1.0E+02	2.0E+03
C-14	5.0E-01	1.0E-03	--	--	1.5E+02	2.1E+01	1.1E+04	--	3.0E+03
Ca-41	1.0E-02	1.0E-03	8.0E+01	8.0E+02	v. lg.	2.1E+03	2.1E+04	--	1.6E+04
Cd-113	1.0E-02	1.0E-03	5.8E-01	5.8E+00	v. lg.	1.0E+00	1.0E+01	--	1.2E+02
Co-60(8)	1.0E-03	1.0E-03	6.0E+01	6.0E+01	v. lg.	1.6E+02	1.6E+02	1.5E+01	2.8E+02
Cs-137	1.0E-02	1.0E-03	3.0E+00	3.0E+01	v. lg.	1.0E+02	1.0E+03	6.5E+01	6.0E+02
Eu-152	1.0E-02	1.0E-03	2.4E+01	2.4E+02	v. lg.	1.0E+01	1.0E+02	3.5E+01	7.0E+02
Eu-154	1.0E-02	1.0E-03	1.5E+01	1.5E+02	v. lg.	1.0E+01	1.0E+02	4.2E+01	8.4E+02
Eu-155	1.0E-02	1.0E-03	1.2E+02	1.2E+03	v. lg.	4.7E+01	4.7E+02	7.0E+02	9.4E+03
H-3	5.0E-01	1.0E-03	--	--	5.9E+03	8.3E+02	4.2E+05	--	1.2E+05
Kr-85	1.0E+00	1.0E-03	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	1.0E-03	2.7E+01	2.7E+02	v. lg.	1.0E+01	1.0E+02	2.3E+01	4.6E+02
Ni-59	1.0E-02	1.0E-03	5.9E+02	5.9E+03	v. lg.	2.1E+03	2.1E+04	--	1.2E+05
Ni-63	1.0E-02	1.0E-03	2.7E+02	2.7E+03	v. lg.	1.0E+03	1.0E+04	--	5.4E+04
Pd-107	1.0E-02	1.0E-03	8.9E+02	8.9E+03	v. lg.	2.1E+02	2.1E+03	--	4.2E+04
Pu-238	1.0E-03	1.0E-03	2.1E+00	2.1E+00	v. lg.	3.1E-02	3.1E-02	--	6.2E-01
Pu-239	1.0E-03	1.0E-03	1.8E+00	1.8E+00	v. lg.	2.6E-02	2.6E-02	1.7E+06	5.2E-01
Pu-240	1.0E-03	1.0E-03	1.8E+00	1.8E+00	v. lg.	2.6E-02	2.6E-02	5.0E+06	5.2E-01
Pu-241	1.0E-03	1.0E-03	9.0E+01	9.0E+01	v. lg.	1.6E+00	1.6E+00	1.4E+08	3.2E+01
Se-79	1.0E-02	1.0E-03	1.8E+01	1.8E+02	v. lg.	3.1E+02	3.1E+03	--	3.6E+03
Sm-151	1.0E-02	1.0E-03	3.0E+02	3.0E+03	v. lg.	5.2E+01	5.2E+02	--	1.0E+04
Sr-90	1.0E-02	1.0E-03	8.2E-01	8.2E+00	v. lg.	2.1E+00	2.1E+01	--	1.6E+02
Tc-99	1.0E-02	1.0E-03	8.9E+01	8.9E+02	2.9E+02	3.6E+02	3.6E+03	--	5.8E+03
U-235	1.0E-03	1.0E-03	3.0E+00	3.0E+00	v. lg.	2.1E-01	2.1E-01	2.7E+02	4.2E+00
U-238	1.0E-03	1.0E-03	3.0E+00	3.0E+00	v. lg.	2.1E-01	2.1E-01	--	4.2E+00
Zr-93	1.0E-02	1.0E-03	3.0E+01	3.0E+02	v. lg.	3.1E+00	3.1E+01	--	6.2E+02

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec) and average breathing rate (2.7E-4 m^3/sec).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky TJR Date: 11/7/06 Calc. No.: 0100X-CA-N0020 Rev. No.: 1
Project: D/DR/H Field Remediation Job No.: 14655 Checked: J. D. Ludowise JDL Date: 11-7-06
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs) Sheet No.: 25 of 38

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
SOIL – DUMPING & DROPPING/IMPACT									
Ag-108m	1.0E-02	1.0E-06	1.8E+01	1.8E+05	v. lg.	1.0E+01	1.0E+05	2.2E+01	4.4E+02
Am-241	1.0E-03	1.0E-06	3.0E-01	3.0E+02	v. lg.	2.6E-02	2.6E+01	--	5.2E+02
Ba-133	1.0E-02	1.0E-06	5.9E+01	5.9E+05	v. lg.	3.6E+02	3.6E+06	1.0E+02	2.0E+03
C-14	5.0E-01	1.0E-06	--	--	1.5E+02	2.1E+01	1.1E+07	--	3.0E+03
Ca-41	1.0E-02	1.0E-06	8.0E+01	8.0E+05	v. lg.	2.1E+03	2.1E+07	--	1.6E+07
Cd-113	1.0E-02	1.0E-06	5.8E-01	5.8E+03	v. lg.	1.0E+00	1.0E+04	--	1.2E+05
Co-60(8)	1.0E-03	1.0E-06	6.0E+01	6.0E+04	v. lg.	1.6E+02	1.6E+05	1.5E+01	2.8E+02
Cs-137	1.0E-02	1.0E-06	3.0E+00	3.0E+04	v. lg.	1.0E+02	1.0E+06	6.5E+01	1.3E+03
Eu-152	1.0E-02	1.0E-06	2.4E+01	2.4E+05	v. lg.	1.0E+01	1.0E+05	3.5E+01	7.0E+02
Eu-154	1.0E-02	1.0E-06	1.5E+01	1.5E+05	v. lg.	1.0E+01	1.0E+05	4.2E+01	8.4E+02
Eu-155	1.0E-02	1.0E-06	1.2E+02	1.2E+06	v. lg.	4.7E+01	4.7E+05	7.0E+02	1.4E+04
H-3	5.0E-01	1.0E-06	--	--	5.9E+03	8.3E+02	4.2E+08	--	1.2E+05
Kr-85	1.0E+00	1.0E-06	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	1.0E-06	2.7E+01	2.7E+05	v. lg.	1.0E+01	1.0E+05	2.3E+01	4.6E+02
Ni-59	1.0E-02	1.0E-06	5.9E+02	5.9E+06	v. lg.	2.1E+03	2.1E+07	--	1.2E+08
Ni-63	1.0E-02	1.0E-06	2.7E+02	2.7E+06	v. lg.	1.0E+03	1.0E+07	--	5.4E+07
Pd-107	1.0E-02	1.0E-06	8.9E+02	8.9E+06	v. lg.	2.1E+02	2.1E+06	--	4.2E+07
Pu-238	1.0E-03	1.0E-06	2.1E+00	2.1E+03	v. lg.	3.1E-02	3.1E+01	--	6.2E+02
Pu-239	1.0E-03	1.0E-06	1.8E+00	1.8E+03	v. lg.	2.6E-02	2.6E+01	1.7E+06	5.2E+02
Pu-240	1.0E-03	1.0E-06	1.8E+00	1.8E+03	v. lg.	2.6E-02	2.6E+01	5.0E+06	5.2E+02
Pu-241	1.0E-03	1.0E-06	9.0E+01	9.0E+04	v. lg.	1.6E+00	1.6E+03	1.4E+08	3.2E+04
Se-79	1.0E-02	1.0E-06	1.8E+01	1.8E+05	v. lg.	3.1E+02	3.1E+06	--	3.6E+06
Sm-151	1.0E-02	1.0E-06	3.0E+02	3.0E+06	v. lg.	5.2E+01	5.2E+05	--	1.0E+07
Sr-90	1.0E-02	1.0E-06	8.2E-01	8.2E+03	v. lg.	2.1E+00	2.1E+04	--	1.6E+05
Tc-99	1.0E-02	1.0E-06	8.9E+01	8.9E+05	2.9E+02	3.6E+02	3.6E+06	--	5.8E+03
U-235	1.0E-03	1.0E-06	3.0E+00	3.0E+03	v. lg.	2.1E-01	2.1E+02	2.7E+02	4.2E+03
U-238	1.0E-03	1.0E-06	3.0E+00	3.0E+03	v. lg.	2.1E-01	2.1E+02	--	4.2E+03
Zr-93	1.0E-02	1.0E-06	3.0E+01	3.0E+05	v. lg.	3.1E+00	3.1E+04	--	6.2E+05

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072$ m^3/sec).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed ($X/Q = 0.072$ m^3/sec) and average breathing rate (2.7E-4 m^3/sec).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc (25) Rev TQ (1E-6)

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TR	**Date:**	11/7/06	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	J. D. Ludowise JDL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	26 of 38

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
LIQUIDS -- ENTRAINMENT									
Ag-108m	1.0E-02	3.2E-05	1.8E+01	5.6E+03	v. lg.	1.0E+01	3.1E+03	2.2E+01	4.4E+02
Am-241	1.0E-03	3.2E-05	3.0E-01	9.4E+00	v. lg.	2.6E-02	8.1E-01	--	1.6E+01
Ba-133	1.0E-02	3.2E-05	5.9E+01	1.8E+04	v. lg.	3.6E+02	1.1E+05	1.0E+02	2.0E+03
C-14	5.0E-01	3.2E-05	--	--	1.5E+02	2.1E+01	3.3E+05	--	3.0E+03
Ca-41	1.0E-02	3.2E-05	8.0E+01	2.5E+04	v. lg.	2.1E+03	6.6E+05	--	5.0E+05
Cd-113	1.0E-02	3.2E-05	5.8E-01	1.8E+02	v. lg.	1.0E+00	3.1E+02	--	3.6E+03
Co-60(8)	1.0E-03	3.2E-05	6.0E+01	1.9E+03	v. lg.	1.6E+02	5.0E+03	1.5E+01	2.8E+02
Cs-137	1.0E-02	3.2E-05	3.0E+00	9.4E+02	v. lg.	1.0E+02	3.1E+04	6.5E+01	1.3E+03
Eu-152	1.0E-02	3.2E-05	2.4E+01	7.5E+03	v. lg.	1.0E+01	3.1E+03	3.5E+01	7.0E+02
Eu-154	1.0E-02	3.2E-05	1.5E+01	4.7E+03	v. lg.	1.0E+01	3.1E+03	4.2E+01	8.4E+02
Eu-155	1.0E-02	3.2E-05	1.2E+02	3.8E+04	v. lg.	4.7E+01	1.5E+04	7.0E+02	1.4E+04
H-3	5.0E-01	3.2E-05	--	--	5.9E+03	8.3E+02	1.3E+07	--	1.2E+05
Kr-85	1.0E+00	3.2E-05	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	3.2E-05	2.7E+01	8.4E+03	v. lg.	1.0E+01	3.1E+03	2.3E+01	4.6E+02
Ni-59	1.0E-02	3.2E-05	5.9E+02	1.8E+05	v. lg.	2.1E+03	6.6E+05	--	3.7E+06
Ni-63	1.0E-02	3.2E-05	2.7E+02	8.4E+04	v. lg.	1.0E+03	3.1E+05	--	1.7E+06
Pd-107	1.0E-02	3.2E-05	8.9E+02	2.8E+05	v. lg.	2.1E+02	6.6E+04	--	1.3E+06
Pu-238	1.0E-03	3.2E-05	2.1E+00	6.6E+01	v. lg.	3.1E-02	9.7E-01	--	1.9E+01
Pu-239	1.0E-03	3.2E-05	1.8E+00	5.6E+01	v. lg.	2.6E-02	8.1E-01	1.7E+06	1.6E+01
Pu-240	1.0E-03	3.2E-05	1.8E+00	5.6E+01	v. lg.	2.6E-02	8.1E-01	5.0E+06	1.6E+01
Pu-241	1.0E-03	3.2E-05	9.0E+01	2.8E+03	v. lg.	1.6E+00	5.0E+01	1.4E+08	1.0E+03
Se-79	1.0E-02	3.2E-05	1.8E+01	5.6E+03	v. lg.	3.1E+02	9.7E+04	--	1.1E+05
Sm-151	1.0E-02	3.2E-05	3.0E+02	9.4E+04	v. lg.	5.2E+01	1.6E+04	--	3.3E+05
Sr-90	1.0E-02	3.2E-05	8.2E-01	2.6E+02	v. lg.	2.1E+00	6.6E+02	--	5.1E+03
Tc-99	1.0E-02	3.2E-05	8.9E+01	2.8E+04	2.9E+02	3.6E+02	1.1E+05	--	5.8E+03
U-235	1.0E-03	3.2E-05	3.0E+00	9.4E+01	v. lg.	2.1E-01	6.6E+00	2.7E+02	1.3E+02
U-238	1.0E-03	3.2E-05	3.0E+00	9.4E+01	v. lg.	2.1E-01	6.6E+00	--	1.3E+02
Zr-93	1.0E-02	3.2E-05	3.0E+01	9.4E+03	v. lg.	3.1E+00	9.7E+02	--	1.9E+04

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec) and average breathing rate (2.7E-4 m^3/sec).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV} The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc (26) Rev TQ (3.2E-5)

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky DR	**Date:**	11/7/06	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	J. D. Ludowise JL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	27 of 38

9.0 Calculation of Revised TQ Values (continued)

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	RV_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation RV(5) (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
LIQUID – DEFLAGRATION									
Ag-108m	1.0E-02	4.0E-05	1.8E+01	4.5E+03	v. lg.	1.0E+01	2.5E+03	2.2E+01	4.4E+02
Am-241	1.0E-03	4.0E-05	3.0E-01	7.5E+00	v. lg.	2.6E-02	6.5E-01	--	1.3E+01
Ba-133	1.0E-02	4.0E-05	5.9E+01	1.5E+04	v. lg.	3.6E+02	9.0E+04	1.0E+02	2.0E+03
C-14	5.0E-01	4.0E-05	--	--	1.5E+02	2.1E+01	2.6E+05	--	3.0E+03
Ca-41	1.0E-02	4.0E-05	8.0E+01	2.0E+04	v. lg.	2.1E+03	5.3E+05	--	4.0E+05
Cd-113	1.0E-02	4.0E-05	5.8E-01	1.5E+02	v. lg.	1.0E+00	2.5E+02	--	2.9E+03
Co-60(8)	1.0E-03	4.0E-05	6.0E+01	1.5E+03	v. lg.	1.6E+02	4.0E+03	1.5E+01	2.8E+02
Cs-137	1.0E-02	4.0E-05	3.0E+00	7.5E+02	v. lg.	1.0E+02	2.5E+04	6.5E+01	1.3E+03
Eu-152	1.0E-02	4.0E-05	2.4E+01	6.0E+03	v. lg.	1.0E+01	2.5E+03	3.5E+01	7.0E+02
Eu-154	1.0E-02	4.0E-05	1.5E+01	3.8E+03	v. lg.	1.0E+01	2.5E+03	4.2E+01	8.4E+02
Eu-155	1.0E-02	4.0E-05	1.2E+02	3.0E+04	v. lg.	4.7E+01	1.2E+04	7.0E+02	1.4E+04
H-3	5.0E-01	4.0E-05	--	--	5.9E+03	8.3E+02	1.0E+07	--	1.2E+05
Kr-85	1.0E+00	4.0E-05	na	na	na	na	na	1.0E+03	2.0E+04
Nb-94	1.0E-02	4.0E-05	2.7E+01	6.8E+03	v. lg.	1.0E+01	2.5E+03	2.3E+01	4.6E+02
Ni-59	1.0E-02	4.0E-05	5.9E+02	1.5E+05	v. lg.	2.1E+03	5.3E+05	--	3.0E+06
Ni-63	1.0E-02	4.0E-05	2.7E+02	6.8E+04	v. lg.	1.0E+03	2.5E+05	--	1.4E+06
Pd-107	1.0E-02	4.0E-05	8.9E+02	2.2E+05	v. lg.	2.1E+02	5.3E+04	--	1.1E+06
Pu-238	1.0E-03	4.0E-05	2.1E+00	5.3E+01	v. lg.	3.1E-02	7.8E-01	--	1.6E+01
Pu-239	1.0E-03	4.0E-05	1.8E+00	4.5E+01	v. lg.	2.6E-02	6.5E-01	1.7E+06	1.3E+01
Pu-240	1.0E-03	4.0E-05	1.8E+00	4.5E+01	v. lg.	2.6E-02	6.5E-01	5.0E+06	1.3E+01
Pu-241	1.0E-03	4.0E-05	9.0E+01	2.3E+03	v. lg.	1.6E+00	4.0E+01	1.4E+08	8.0E+02
Se-79	1.0E-02	4.0E-05	1.8E+01	4.5E+03	v. lg.	3.1E+02	7.8E+04	--	9.0E+04
Sm-151	1.0E-02	4.0E-05	3.0E+02	7.5E+04	v. lg.	5.2E+01	1.3E+04	--	2.6E+05
Sr-90	1.0E-02	4.0E-05	8.2E-01	2.1E+02	v. lg.	2.1E+00	5.3E+02	--	4.1E+03
Tc-99	1.0E-02	4.0E-05	8.9E+01	2.2E+04	2.9E+02	3.6E+02	9.0E+04	--	5.8E+03
U-235	1.0E-03	4.0E-05	3.0E+00	7.5E+01	v. lg.	2.1E-01	5.3E+00	2.7E+02	1.1E+02
U-238	1.0E-03	4.0E-05	3.0E+00	7.5E+01	v. lg.	2.1E-01	5.3E+00	--	1.1E+02
Zr-93	1.0E-02	4.0E-05	3.0E+01	7.5E+03	v. lg.	3.1E+00	7.8E+02	--	1.6E+04

Notes:

v. lg. = the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- = no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

na = an annual limit intake (ALI) for either ingestion or inhalation (or both) was unavailable for this radionuclide.

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / RV_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec) and average breathing rate (2.7E-4 m^3/sec).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky DR	**Date:**	11/7/06	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	J. D. Ludowise JDL	**Date:**	11-2-06
Subject:						**Sheet No.:**	28 of 38

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)

10.0 Sum of the Ratios

10.1 Spent Fuel Elements (Oxide) -- Fire, Dumping, Entrainment, Dropping/Impact

Fire			
		1027 CATEGORY 3	
Isotope	**Spent Fuel Element (Oxide) Inventory (25 Elements) (Ci)[1]**	**$TQ_{REVISED}$ (Ci)[2]**	**RATIO**
Ag-108m	0.00E+00	4.4E+02	0.00E+00
Am-241	2.96E-03	8.7E+00	3.41E-04
Ba-133	0.00E+00	2.0E+03	0.00E+00
C-14	0.00E+00	3.0E+03	0.00E+00
Ca-41	0.00E+00	2.7E+05	0.00E+00
Cd-113m	3.87E-06	1.9E+03	2.00E-09
Co-60	0.00E+00	2.8E+02	0.00E+00
Cs-137	1.26E-01	1.3E+03	9.72E-05
Eu-152	5.33E-07	7.0E+02	7.62E-10
Eu-154	0.00E+00	8.4E+02	0.00E+00
Eu-155	0.00E+00	1.4E+04	0.00E+00
H-3	0.00E+00	1.2E+05	0.00E+00
Kr-85	2.74E-03	2.0E+04	1.37E-07
Nb-94	4.00E-06	4.6E+02	8.69E-09
Ni-59	0.00E+00	2.0E+06	0.00E+00
Ni-63	0.00E+00	9.0E+05	0.00E+00
Pd-107	1.00E-07	7.0E+05	1.43E-13
Pu-238	8.54E-05	1.0E+01	8.26E-06
Pu-239	6.00E-03	8.7E+00	6.92E-04
Pu-240	1.50E-03	8.7E+00	1.73E-04
Pu-241	1.95E-02	5.3E+02	3.65E-05
Se-79	1.00E-06	6.0E+04	1.67E-11
Sm-151	1.71E-03	1.7E+05	9.89E-09
Sr-90	1.24E-01	2.7E+03	4.54E-05
Tc-99	5.00E-03	5.8E+03	8.62E-07
U-235	0.00E+00	7.0E+01	0.00E+00
U-238	3.00E-05	7.0E+01	4.29E-07
Zr-93	1.00E-05	1.0E+04	9.68E-10
			1.39E-03

Dumping, Entrainment, Dropping/Impact			
		1027 CATEGORY 3	
Isotope	**Spent Fuel Element (Oxide) Inventory (25 Elements) (Ci)[1]**	**$TQ_{REVISED}$ (Ci)[3]**	**RATIO**
Ag-108m	0.00E+00	4.4E+02	0.00E+00
Am-241	2.96E-03	5.2E-01	5.69E-03
Ba-133	0.00E+00	2.0E+03	0.00E+00
C-14	0.00E+00	3.0E+03	0.00E+00
Ca-41	0.00E+00	1.6E+04	0.00E+00
Cd-113m	3.87E-06	1.2E+02	3.34E-08
Co-60	0.00E+00	2.8E+02	0.00E+00
Cs-137	1.26E-01	6.0E+02	2.11E-04
Eu-152	5.33E-07	7.0E+02	7.62E-10
Eu-154	0.00E+00	8.4E+02	0.00E+00
Eu-155	0.00E+00	9.4E+03	0.00E+00
H-3	0.00E+00	1.2E+05	0.00E+00
Kr-85	2.74E-03	2.0E+04	1.37E-07
Nb-94	4.00E-06	4.6E+02	8.69E-09
Ni-59	0.00E+00	1.2E+05	0.00E+00
Ni-63	0.00E+00	5.4E+04	0.00E+00
Pd-107	1.00E-07	4.2E+04	2.38E-12
Pu-238	8.54E-05	6.2E-01	1.38E-04
Pu-239	6.00E-03	5.2E-01	1.15E-02
Pu-240	1.50E-03	5.2E-01	2.88E-03
Pu-241	1.95E-02	3.2E+01	6.09E-04
Se-79	1.00E-06	3.6E+03	2.78E-10
Sm-151	1.71E-03	1.0E+04	1.65E-07
Sr-90	1.24E-01	1.6E+02	7.56E-04
Tc-99	5.00E-03	5.8E+03	8.62E-07
U-235	0.00E+00	4.2E+00	0.00E+00
U-238	3.00E-05	4.2E+00	7.14E-06
Zr-93	1.00E-05	6.2E+02	1.61E-08
			2.18E-02

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 100% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 21.

[3]The revised TQ values are calculated on Sheet 24.

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TJR	**Date:**	11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:** 1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:** J. D. Ludowise JDL	**Date:** 11-2-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)				**Sheet No.:** 29 of 38

10.2 Spent Fuel Elements (Oxide) -- Deflagration

Isotope	Spent Fuel Element (Oxide) Inventory (25 Elements) (Ci)[1]	1027 CATEGORY 3	
		$TQ_{REVISED}$ (Ci)[2]	RATIO
Ag-108m	0.00E+00	4.4E+02	0.00E+00
Am-241	2.96E-03	2.6E-01	1.14E-02
Ba-133	0.00E+00	2.0E+03	0.00E+00
C-14	0.00E+00	3.0E+03	0.00E+00
Ca-41	0.00E+00	8.0E+03	0.00E+00
Cd-113m	3.87E-06	5.8E+01	6.67E-08
Co-60	0.00E+00	2.8E+02	0.00E+00
Cs-137	1.26E-01	3.0E+02	4.21E-04
Eu-152	5.33E-07	7.0E+02	7.62E-10
Eu-154	0.00E+00	8.4E+02	0.00E+00
Eu-155	0.00E+00	4.7E+03	0.00E+00
H-3	0.00E+00	1.2E+05	0.00E+00
Kr-85	2.74E-03	2.0E+04	1.37E-07
Nb-94	4.00E-06	4.6E+02	8.69E-09
Ni-59	0.00E+00	5.9E+04	0.00E+00
Ni-63	0.00E+00	2.7E+04	0.00E+00
Pd-107	1.00E-07	2.1E+04	4.76E-12
Pu-238	8.54E-05	3.1E-01	2.75E-04
Pu-239	6.00E-03	2.6E-01	2.31E-02
Pu-240	1.50E-03	2.6E-01	5.76E-03
Pu-241	1.95E-02	1.6E+01	1.22E-03
Se-79	1.00E-06	1.8E+03	5.55E-10
Sm-151	1.71E-03	5.2E+03	3.30E-07
Sr-90	1.24E-01	8.2E+01	1.51E-03
Tc-99	5.00E-03	5.8E+03	8.62E-07
U-235	0.00E+00	2.1E+00	0.00E+00
U-238	3.00E-05	2.1E+00	1.43E-05
Zr-93	1.00E-05	3.1E+02	3.23E-08
			4.36E-02

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 100% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 20.

Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky DR Date: 11/7/06 Calc. No.: 0100X-CA-N0020 Rev. No.: 1
Project: D/DR/H Field Remediation Job No.: 14655 Checked: J. D. Ludowise Date: 11-7-06
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs) Sheet No.: 30 of 38

10.3 Spent Fuel Elements (Metal) -- Fire

Isotope	Spent Fuel Element Inventory (25 Elements) (Ci)[1]	1027 CATEGORY 3 $TQ_{REVISED}$ (Ci)[2]	1027 CATEGORY 3 RATIO
Ag-108m	0.00E+00	4.4E+02	0.00E+00
Am-241	2.96E-01	5.2E+00	5.69E-02
Ba-133	0.00E+00	2.0E+03	0.00E+00
C-14	0.00E+00	3.0E+03	0.00E+00
Ca-41	0.00E+00	1.6E+05	0.00E+00
Cd-113m	3.87E-04	1.2E+03	3.34E-07
Co-60	0.00E+00	2.8E+02	0.00E+00
Cs-137	1.26E+01	1.3E+03	9.72E-03
Eu-152	5.33E-05	7.0E+02	7.62E-08
Eu-154	0.00E+00	8.4E+02	0.00E+00
Eu-155	0.00E+00	1.4E+04	0.00E+00
H-3	0.00E+00	1.2E+05	0.00E+00
Kr-85	2.74E-01	2.0E+04	1.37E-05
Nb-94	4.00E-04	4.6E+02	8.69E-07
Ni-59	0.00E+00	1.2E+06	0.00E+00
Ni-63	0.00E+00	5.4E+05	0.00E+00
Pd-107	1.00E-05	4.2E+05	2.38E-11
Pu-238	8.54E-03	6.2E+00	1.38E-03
Pu-239	6.00E-01	5.2E+00	1.15E-01
Pu-240	1.50E-01	5.2E+00	2.88E-02
Pu-241	1.95E+00	3.2E+02	6.09E-03
Se-79	1.00E-04	3.6E+04	2.78E-09
Sm-151	1.71E-01	1.0E+05	1.65E-06
Sr-90	1.24E+01	1.6E+03	7.56E-03
Tc-99	5.00E-01	5.8E+03	8.62E-05
U-235	0.00E+00	4.2E+01	0.00E+00
U-238	3.00E-03	4.2E+01	7.14E-05
Zr-93	1.00E-03	6.2E+03	1.61E-07
			2.26E-01

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:
[1]Inventory from Sheet 16 and takes into consideration 10% of inventory (Section 7.7).
[2]The revised TQ values are calculated on Sheet 22.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc(30) (10.3)

Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky TR **Date:** 11/7/06 **Calc. No.:** 0100X-CA-N0020 **Rev. No.:** 1
Project: D/DR/H Field Remediation **Job No.:** 14655 **Checked:** J. D. Ludowise JL **Date:** 11-7-06
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs) **Sheet No.:** 31 of 38

10.4 Soil -- Deflagration and Fire

Fire

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 TQ$_{REVISED}$ (Ci)[2]	1027 CATEGORY 3 RATIO
Ag-108m	1.35E+00	4.4E+02	3.07E-03
Am-241	1.43E-01	3.5E+04	4.14E-06
Ba-133	2.03E-02	2.0E+03	1.01E-05
C-14	1.42E-01	3.0E+03	4.75E-05
Ca-41	1.41E-03	1.1E+09	1.32E-12
Cd-113m	0.00E+00	7.7E+06	0.00E+00
Co-60	4.55E+00	2.8E+02	1.63E-02
Cs-137	1.88E+01	1.3E+03	1.44E-02
Eu-152	1.22E-01	7.0E+02	1.75E-04
Eu-154	4.27E-02	8.4E+02	5.08E-05
Eu-155	1.87E-02	1.4E+04	1.34E-06
H-3	2.72E+01	1.2E+05	2.30E-04
Kr-85	6.72E-01	2.0E+04	3.36E-05
Nb-94	4.52E-03	4.6E+02	9.83E-06
Ni-59	8.66E-01	7.9E+09	1.10E-10
Ni-63	3.23E+01	3.6E+09	8.98E-09
Pd-107	0.00E+00	2.8E+09	0.00E+00
Pu-238	7.37E-03	4.1E+04	1.78E-07
Pu-239	8.92E-03	3.5E+04	2.57E-07
Pu-240	0.00E+00	3.5E+04	0.00E+00
Pu-241	0.00E+00	2.1E+06	0.00E+00
Se-79	7.88E-02	2.4E+08	3.28E-10
Sm-151	0.00E+00	6.9E+08	0.00E+00
Sr-90	1.99E-01	1.1E+07	1.82E-08
Tc-99	1.41E-02	5.8E+03	2.43E-06
U-235	1.06E-02	5.4E+03	1.96E-06
U-238	1.08E-02	2.8E+05	3.86E-08
Zr-93	0.00E+00	4.1E+07	0.00E+00
			3.43E-02

Deflagration

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 TQ$_{REVISED}$ (Ci)[2]	1027 CATEGORY 3 RATIO
Ag-108m	1.35E-02	4.4E+02	3.07E-05
Am-241	1.43E-03	3.5E+04	4.14E-08
Ba-133	2.03E-04	2.0E+03	1.01E-07
C-14	1.42E-03	3.0E+03	4.75E-07
Ca-41	1.41E-05	1.1E+09	1.32E-14
Cd-113m	0.00E+00	7.7E+06	0.00E+00
Co-60	4.55E-02	2.8E+02	1.63E-04
Cs-137	1.88E-01	1.3E+03	1.44E-04
Eu-152	1.22E-03	7.0E+02	1.75E-06
Eu-154	4.27E-04	8.4E+02	5.08E-07
Eu-155	1.87E-04	1.4E+04	1.34E-08
H-3	2.72E-01	1.2E+05	2.30E-06
Kr-85	6.72E-03	2.0E+04	3.36E-07
Nb-94	4.52E-05	4.6E+02	9.83E-08
Ni-59	8.66E-03	7.9E+09	1.10E-12
Ni-63	3.23E-01	3.6E+09	8.98E-11
Pd-107	0.00E+00	2.8E+09	0.00E+00
Pu-238	7.37E-05	4.1E+04	1.78E-09
Pu-239	8.92E-05	3.5E+04	2.57E-09
Pu-240	0.00E+00	3.5E+04	0.00E+00
Pu-241	0.00E+00	2.1E+06	0.00E+00
Se-79	7.88E-04	2.4E+08	3.28E-12
Sm-151	0.00E+00	6.9E+08	0.00E+00
Sr-90	1.99E-03	1.1E+07	1.82E-10
Tc-99	1.41E-04	5.8E+03	2.43E-08
U-235	1.06E-04	5.4E+03	1.96E-08
U-238	1.08E-04	2.8E+05	3.86E-10
Zr-93	0.00E+00	4.1E+07	0.00E+00
			3.43E-04

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1] Inventory from Sheet 16 and takes into consideration 100% of inventory for fire and 1% of inventory for deflagration (Section 7.7).

[2] The revised TQ values are calculated on Sheet 19.

Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky DR	**Date:** 11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:** 1		
Project: D/DR/H Field Remediation	**Job No.:** 14655	**Checked:** J. D. Ludowise JDL	**Date:** 11-7-06		
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			**Sheet No.:** 32 of 38		

10.5 Combustible Materials – Deflagration, Dropping/Impact and Fire

Fire

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 TQ$_{REVISED}$ (Ci)[2]	1027 CATEGORY 3 RATIO
Ag-108m	4.80E-01	4.4E+02	1.09E-03
Am-241	5.09E-02	1.0E+00	4.89E-02
Ba-133	7.20E-03	2.0E+03	3.60E-06
C-14	5.05E-02	3.0E+03	1.68E-05
Ca-41	5.00E-04	3.2E+04	1.56E-08
Cd-113m	0.00E+00	2.3E+02	0.00E+00
Co-60	1.61E+00	2.8E+02	5.76E-03
Cs-137	6.66E+00	1.2E+03	5.55E-03
Eu-152	4.34E-02	7.0E+02	6.20E-05
Eu-154	1.51E-02	8.4E+02	1.80E-05
Eu-155	6.65E-03	1.4E+04	4.75E-07
H-3	9.64E+00	1.2E+05	8.17E-05
Kr-85	2.38E-01	2.0E+04	1.19E-05
Nb-94	1.60E-03	4.6E+02	3.49E-06
Ni-59	3.07E-01	2.4E+05	1.30E-06
Ni-63	1.15E+01	1.1E+05	1.06E-04
Pd-107	0.00E+00	8.4E+04	0.00E+00
Pu-238	2.61E-03	1.2E+00	2.11E-03
Pu-239	3.16E-03	1.0E+00	3.04E-03
Pu-240	0.00E+00	1.0E+00	0.00E+00
Pu-241	0.00E+00	6.4E+01	0.00E+00
Se-79	2.80E-02	7.2E+03	3.88E-06
Sm-151	0.00E+00	2.1E+04	0.00E+00
Sr-90	7.07E-02	3.3E+02	2.16E-04
Tc-99	4.99E-03	5.8E+03	8.61E-07
U-235	3.76E-03	8.4E+00	4.47E-04
U-238	3.83E-03	8.4E+00	4.56E-04
Zr-93	0.00E+00	1.2E+03	0.00E+00
			6.79E-02

Deflagration & Dropping /Impact

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 TQ$_{REVISED}$ (Ci)[3]	1027 CATEGORY 3 RATIO
Ag-108m	4.80E-03	4.4E+02	1.09E-05
Am-241	5.09E-04	5.2E-01	9.78E-04
Ba-133	7.20E-05	2.0E+03	3.60E-08
C-14	5.05E-04	3.0E+03	1.68E-07
Ca-41	5.00E-06	1.6E+04	3.12E-10
Cd-113m	0.00E+00	1.2E+02	0.00E+00
Co-60	1.61E-02	2.8E+02	5.76E-05
Cs-137	6.66E-02	6.0E+02	1.11E-04
Eu-152	4.34E-04	7.0E+02	6.20E-07
Eu-154	1.51E-04	8.4E+02	1.80E-07
Eu-155	6.65E-05	9.4E+03	7.07E-09
H-3	9.64E-02	1.2E+05	8.17E-07
Kr-85	2.38E-03	2.0E+04	1.19E-07
Nb-94	1.60E-05	4.6E+02	3.49E-08
Ni-59	3.07E-03	1.2E+05	2.60E-08
Ni-63	1.15E-01	5.4E+04	2.12E-06
Pd-107	0.00E+00	4.2E+04	0.00E+00
Pu-238	2.61E-05	6.2E-01	4.21E-05
Pu-239	3.16E-05	5.2E-01	6.08E-05
Pu-240	0.00E+00	5.2E-01	0.00E+00
Pu-241	0.00E+00	3.2E+01	0.00E+00
Se-79	2.80E-04	3.6E+03	7.76E-08
Sm-151	0.00E+00	1.0E+04	0.00E+00
Sr-90	7.07E-04	1.6E+02	4.31E-06
Tc-99	4.99E-05	5.8E+03	8.61E-09
U-235	3.76E-05	4.2E+00	8.95E-06
U-238	3.83E-05	4.2E+00	9.12E-06
Zr-93	0.00E+00	6.2E+02	0.00E+00
			1.29E-03

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 100% of inventory for fire and 1% of inventory for deflagration and dropping/impact (Section 7.7).

[2]The revised TQ values are calculated on Sheet 23.

[3]The revised TQ values are calculated on Sheet 24.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc(32) (10.5)

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky DL	Date:	11/7/06	Calc. No.: 0100X-CA-N0020	Rev. No.: 1
Project:	D/DR/H Field Remediation	Job No.:	14655	Checked: J. D. Ludowise JL	Date: 11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)				Sheet No.: 33 of 38

10.6 Noncombustible Materials -- Deflagration, Dumping and Dropping/Impact

Deflagration			
		1027 CATEGORY 3	
Isotope	Radionuclide Inventory (Ci)[1]	$TQ_{REVISED}$ (Ci)[2]	RATIO
Ag-108m	7.66E-02	4.4E+02	1.74E-04
Am-241	8.13E-03	5.2E+02	1.56E-05
Ba-133	1.15E-03	2.0E+03	5.75E-07
C-14	8.07E-03	3.0E+03	2.69E-06
Ca-41	7.99E-05	1.6E+07	4.99E-12
Cd-113m	0.00E+00	1.2E+05	0.00E+00
Co-60	2.58E-01	2.8E+02	9.21E-04
Cs-137	1.06E+00	1.3E+03	8.19E-04
Eu-152	6.94E-03	7.0E+02	9.91E-06
Eu-154	2.42E-03	8.4E+02	2.88E-06
Eu-155	1.06E-03	1.4E+04	7.59E-08
H-3	1.54E+00	1.2E+05	1.31E-05
Kr-85	3.81E-02	2.0E+04	1.90E-06
Nb-94	2.56E-04	4.6E+02	5.57E-07
Ni-59	4.91E-02	1.2E+08	4.16E-10
Ni-63	1.83E+00	5.4E+07	3.39E-08
Pd-107	0.00E+00	4.2E+07	0.00E+00
Pu-238	4.17E-04	6.2E+02	6.73E-07
Pu-239	5.05E-04	5.2E+02	9.72E-07
Pu-240	0.00E+00	5.2E+02	0.00E+00
Pu-241	0.00E+00	3.2E+04	0.00E+00
Se-79	4.47E-03	3.6E+06	1.24E-09
Sm-151	0.00E+00	1.0E+07	0.00E+00
Sr-90	1.13E-02	1.6E+05	6.89E-08
Tc-99	7.98E-04	5.8E+03	1.38E-07
U-235	6.00E-04	4.2E+03	1.43E-07
U-238	6.12E-04	4.2E+03	1.46E-07
Zr-93	0.00E+00	6.2E+05	0.00E+00
			1.96E-03

Dumping and Dropping/Impact			
		1027 CATEGORY 3	
Isotope	Radionuclide Inventory (Ci)[1]	$TQ_{REVISED}$ (Ci)[3]	RATIO
Ag-108m	7.66E-02	4.4E+02	1.74E-04
Am-241	8.13E-03	5.2E-01	1.56E-02
Ba-133	1.15E-03	2.0E+03	5.75E-07
C-14	8.07E-03	3.0E+03	2.69E-06
Ca-41	7.99E-05	1.6E+04	4.99E-09
Cd-113m	0.00E+00	1.2E+02	0.00E+00
Co-60	2.58E-01	2.8E+02	9.21E-04
Cs-137	1.06E+00	6.0E+02	1.77E-03
Eu-152	6.94E-03	7.0E+02	9.91E-06
Eu-154	2.42E-03	8.4E+02	2.88E-06
Eu-155	1.06E-03	9.4E+03	1.13E-07
H-3	1.54E+00	1.2E+05	1.31E-05
Kr-85	3.81E-02	2.0E+04	1.90E-06
Nb-94	2.56E-04	4.6E+02	5.57E-07
Ni-59	4.91E-02	1.2E+05	4.16E-07
Ni-63	1.83E+00	5.4E+04	3.39E-05
Pd-107	0.00E+00	4.2E+04	0.00E+00
Pu-238	4.17E-04	6.2E-01	6.73E-04
Pu-239	5.05E-04	5.2E-01	9.72E-04
Pu-240	0.00E+00	5.2E-01	0.00E+00
Pu-241	0.00E+00	3.2E+01	0.00E+00
Se-79	4.47E-03	3.6E+03	1.24E-06
Sm-151	0.00E+00	1.0E+04	0.00E+00
Sr-90	1.13E-02	1.6E+02	6.89E-05
Tc-99	7.98E-04	5.8E+03	1.38E-07
U-235	6.00E-04	4.2E+00	1.43E-04
U-238	6.12E-04	4.2E+00	1.46E-04
Zr-93	0.00E+00	6.2E+02	0.00E+00
			2.06E-02

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 1% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 25.

[3]The revised TQ values are calculated on Sheet 24.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc(33) (10.6)

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky DR	**Date:**	11/7/06	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	J. D. Ludowise JL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	34 of 38

10.7 Noncombustible Materials -- Fire & Entrainment

Fire

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 $TQ_{REVISED}$ (Ci)[2]	1027 CATEGORY 3 RATIO
Ag-108m	7.66E-01	4.4E+02	1.74E-03
Am-241	8.13E-02	1.6E+01	5.00E-03
Ba-133	1.15E-02	2.0E+03	5.75E-06
C-14	8.07E-02	3.0E+03	2.69E-05
Ca-41	7.99E-04	5.0E+05	1.60E-09
Cd-113m	0.00E+00	3.6E+03	0.00E+00
Co-60	2.58E+00	2.8E+02	9.21E-03
Cs-137	1.06E+01	1.3E+03	8.19E-03
Eu-152	6.94E-02	7.0E+02	9.91E-05
Eu-154	2.42E-02	8.4E+02	2.88E-05
Eu-155	1.06E-02	1.4E+04	7.59E-07
H-3	1.54E+01	1.2E+05	1.31E-04
Kr-85	3.81E-01	2.0E+04	1.90E-05
Nb-94	2.56E-03	4.6E+02	5.57E-06
Ni-59	4.91E-01	3.7E+06	1.33E-07
Ni-63	1.83E+01	1.7E+06	1.09E-05
Pd-107	0.00E+00	1.3E+06	0.00E+00
Pu-238	4.17E-03	1.9E+01	2.15E-04
Pu-239	5.05E-03	1.6E+01	3.11E-04
Pu-240	0.00E+00	1.6E+01	0.00E+00
Pu-241	0.00E+00	1.0E+03	0.00E+00
Se-79	4.47E-02	1.1E+05	3.97E-07
Sm-151	0.00E+00	3.3E+05	0.00E+00
Sr-90	1.13E-01	5.1E+03	2.20E-05
Tc-99	7.98E-03	5.8E+03	1.38E-06
U-235	6.00E-03	1.3E+02	4.57E-05
U-238	6.12E-03	1.3E+02	4.66E-05
Zr-93	0.00E+00	1.9E+04	0.00E+00
			2.51E-02

Entrainment

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 $TQ_{REVISED}$ (Ci)[3]	1027 CATEGORY 3 RATIO
Ag-108m	7.66E-01	4.4E+02	1.74E-03
Am-241	8.13E-02	5.2E-01	1.56E-01
Ba-133	1.15E-02	2.0E+03	5.75E-06
C-14	8.07E-02	3.0E+03	2.69E-05
Ca-41	7.99E-04	1.6E+04	4.99E-08
Cd-113m	0.00E+00	1.2E+02	0.00E+00
Co-60	2.58E+00	2.8E+02	9.21E-03
Cs-137	1.06E+01	6.0E+02	1.77E-02
Eu-152	6.94E-02	7.0E+02	9.91E-05
Eu-154	2.42E-02	8.4E+02	2.88E-05
Eu-155	1.06E-02	9.4E+03	1.13E-06
H-3	1.54E+01	1.2E+05	1.31E-04
Kr-85	3.81E-01	2.0E+04	1.90E-05
Nb-94	2.56E-03	4.6E+02	5.57E-06
Ni-59	4.91E-01	1.2E+05	4.16E-06
Ni-63	1.83E+01	5.4E+04	3.39E-04
Pd-107	0.00E+00	4.2E+04	0.00E+00
Pu-238	4.17E-03	6.2E-01	6.73E-03
Pu-239	5.05E-03	5.2E-01	9.72E-03
Pu-240	0.00E+00	5.2E-01	0.00E+00
Pu-241	0.00E+00	3.2E+01	0.00E+00
Se-79	4.47E-02	3.6E+03	1.24E-05
Sm-151	0.00E+00	1.0E+04	0.00E+00
Sr-90	1.13E-01	1.6E+02	6.89E-04
Tc-99	7.98E-03	5.8E+03	1.38E-06
U-235	6.00E-03	4.2E+00	1.43E-03
U-238	6.12E-03	4.2E+00	1.46E-03
Zr-93	0.00E+00	6.2E+02	0.00E+00
			2.06E-01

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 10% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 26.

[3]The revised TQ values are calculated on Sheet 24.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc(34)(10.7)

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TJR	**Date:**	11/7/06	**Calc. No.:**	0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:**	14655	**Checked:**	J. D. Ludowise JDL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)					**Sheet No.:**	35 of 38

10.8 Liquid -- Deflagration & Entrainment

Deflagration			
		1027 CATEGORY 3	
Isotope	Radionuclide Inventory (Ci)[1]	$TQ_{REVISED}$ (Ci)[2]	RATIO
Ag-108m	9.59E-02	4.4E+02	2.18E-04
Am-241	1.02E-02	1.3E+01	7.83E-04
Ba-133	1.44E-03	2.0E+03	7.20E-07
C-14	1.01E-02	3.0E+03	3.37E-06
Ca-41	1.00E-04	4.0E+05	2.50E-10
Cd-113m	0.00E+00	2.9E+03	0.00E+00
Co-60	3.23E-01	2.8E+02	1.15E-03
Cs-137	1.33E+00	1.3E+03	1.02E-03
Eu-152	8.69E-03	7.0E+02	1.24E-05
Eu-154	3.02E-03	8.4E+02	3.60E-06
Eu-155	1.33E-03	1.4E+04	9.49E-08
H-3	1.93E+00	1.2E+05	1.63E-05
Kr-85	4.77E-02	2.0E+04	2.38E-06
Nb-94	3.21E-04	4.6E+02	6.97E-07
Ni-59	6.14E-02	3.0E+06	2.08E-08
Ni-63	2.29E+00	1.4E+06	1.70E-06
Pd-107	0.00E+00	1.1E+06	0.00E+00
Pu-238	5.22E-04	1.6E+01	3.37E-05
Pu-239	6.32E-04	1.3E+01	4.86E-05
Pu-240	0.00E+00	1.3E+01	0.00E+00
Pu-241	0.00E+00	8.0E+02	0.00E+00
Se-79	5.59E-03	9.0E+04	6.21E-08
Sm-151	0.00E+00	2.6E+05	0.00E+00
Sr-90	1.41E-02	4.1E+03	3.45E-06
Tc-99	9.99E-04	5.8E+03	1.72E-07
U-235	7.51E-04	1.1E+02	7.16E-06
U-238	7.66E-04	1.1E+02	7.30E-06
Zr-93	0.00E+00	1.6E+04	0.00E+00
			3.32E-03

Entrainment			
		1027 CATEGORY 3	
Isotope	Radionuclide Inventory (Ci)[1]	$TQ_{REVISED}$ (Ci)[3]	RATIO
Ag-108m	9.59E-02	4.4E+02	2.18E-04
Am-241	1.02E-02	1.6E+01	6.26E-04
Ba-133	1.44E-03	2.0E+03	7.20E-07
C-14	1.01E-02	3.0E+03	3.37E-06
Ca-41	1.00E-04	5.0E+05	2.00E-10
Cd-113m	0.00E+00	3.6E+03	0.00E+00
Co-60	3.23E-01	2.8E+02	1.15E-03
Cs-137	1.33E+00	1.3E+03	1.02E-03
Eu-152	8.69E-03	7.0E+02	1.24E-05
Eu-154	3.02E-03	8.4E+02	3.60E-06
Eu-155	1.33E-03	1.4E+04	9.49E-08
H-3	1.93E+00	1.2E+05	1.63E-05
Kr-85	4.77E-02	2.0E+04	2.38E-06
Nb-94	3.21E-04	4.6E+02	6.97E-07
Ni-59	6.14E-02	3.7E+06	1.67E-08
Ni-63	2.29E+00	1.7E+06	1.36E-06
Pd-107	0.00E+00	1.3E+06	0.00E+00
Pu-238	5.22E-04	1.9E+01	2.70E-05
Pu-239	6.32E-04	1.6E+01	3.89E-05
Pu-240	0.00E+00	1.6E+01	0.00E+00
Pu-241	0.00E+00	1.0E+03	0.00E+00
Se-79	5.59E-03	1.1E+05	4.97E-08
Sm-151	0.00E+00	3.3E+05	0.00E+00
Sr-90	1.41E-02	5.1E+03	2.76E-06
Tc-99	9.99E-04	5.8E+03	1.72E-07
U-235	7.51E-04	1.3E+02	5.73E-06
U-238	7.66E-04	1.3E+02	5.84E-06
Zr-93	0.00E+00	1.9E+04	0.00E+00
			3.14E-03

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 100% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 27.

[3]The revised TQ values are calculated on Sheet 26.

0100X-CA-N0020_FHC_Rev0_markup -4/Calc(35) (10.8)

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky DA	**Date:** 11/7/06	**Calc. No.:** 0100X-CA-N0020	**Rev. No.:**	1
Project:	D/DR/H Field Remediation	**Job No.:** 14655	**Checked:** J. D. Ludowise JDL	**Date:**	11-7-06
Subject:	118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)			**Sheet No.:**	36 of 38

10.9 Liquid – Fire, Dumping & Dropping/Impact

Fire			
	Radionuclide Inventory	1027 CATEGORY 3	
Isotope	(Ci)[1]	$TQ_{REVISED}$ (Ci)[2]	RATIO
Ag-108m	9.59E-02	4.4E+02	2.18E-04
Am-241	1.02E-02	2.6E-01	3.91E-02
Ba-133	1.44E-03	2.0E+03	7.20E-07
C-14	1.01E-02	3.0E+03	3.37E-06
Ca-41	1.00E-04	8.0E+03	1.25E-08
Cd-113m	0.00E+00	5.8E+01	0.00E+00
Co-60	3.23E-01	2.8E+02	1.15E-03
Cs-137	1.33E+00	3.0E+02	4.44E-03
Eu-152	8.69E-03	7.0E+02	1.24E-05
Eu-154	3.02E-03	8.4E+02	3.60E-06
Eu-155	1.33E-03	4.7E+03	2.83E-07
H-3	1.93E+00	1.2E+05	1.63E-05
Kr-85	4.77E-02	2.0E+04	2.38E-06
Nb-94	3.21E-04	4.6E+02	6.97E-07
Ni-59	6.14E-02	5.9E+04	1.04E-06
Ni-63	2.29E+00	2.7E+04	8.50E-05
Pd-107	0.00E+00	2.1E+04	0.00E+00
Pu-238	5.22E-04	3.1E-01	1.69E-03
Pu-239	6.32E-04	2.6E-01	2.43E-03
Pu-240	0.00E+00	2.6E-01	0.00E+00
Pu-241	0.00E+00	1.6E+01	0.00E+00
Se-79	5.59E-03	1.8E+03	3.11E-06
Sm-151	0.00E+00	5.2E+03	0.00E+00
Sr-90	1.41E-02	8.2E+01	1.72E-04
Tc-99	9.99E-04	5.8E+03	1.72E-07
U-235	7.51E-04	2.1E+00	3.58E-04
U-238	7.66E-04	2.1E+00	3.65E-04
Zr-93	0.00E+00	3.1E+02	0.00E+00
			5.01E-02

Dumping & Dropping/Impact			
	Radionuclide Inventory	1027 CATEGORY 3	
Isotope	(Ci)[1]	$TQ_{REVISED}$ (Ci)[3]	RATIO
Ag-108m	9.59E-02	4.4E+02	2.18E-04
Am-241	1.02E-02	5.2E+00	1.96E-03
Ba-133	1.44E-03	2.0E+03	7.20E-07
C-14	1.01E-02	3.0E+03	3.37E-06
Ca-41	1.00E-04	1.6E+05	6.25E-10
Cd-113m	0.00E+00	1.2E+03	0.00E+00
Co-60	3.23E-01	2.8E+02	1.15E-03
Cs-137	1.33E+00	1.3E+03	1.02E-03
Eu-152	8.69E-03	7.0E+02	1.24E-05
Eu-154	3.02E-03	8.4E+02	3.60E-06
Eu-155	1.33E-03	1.4E+04	9.49E-08
H-3	1.93E+00	1.2E+05	1.63E-05
Kr-85	4.77E-02	2.0E+04	2.38E-06
Nb-94	3.21E-04	4.6E+02	6.97E-07
Ni-59	6.14E-02	1.2E+06	5.20E-08
Ni-63	2.29E+00	5.4E+05	4.25E-06
Pd-107	0.00E+00	4.2E+05	0.00E+00
Pu-238	5.22E-04	6.2E+00	8.43E-05
Pu-239	6.32E-04	5.2E+00	1.22E-04
Pu-240	0.00E+00	5.2E+00	0.00E+00
Pu-241	0.00E+00	3.2E+02	0.00E+00
Se-79	5.59E-03	3.6E+04	1.55E-07
Sm-151	0.00E+00	1.0E+05	0.00E+00
Sr-90	1.41E-02	1.6E+03	8.62E-06
Tc-99	9.99E-04	5.8E+03	1.72E-07
U-235	7.51E-04	4.2E+01	1.79E-05
U-238	7.66E-04	4.2E+01	1.82E-05
Zr-93	0.00E+00	6.2E+03	0.00E+00
			4.65E-03

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 100% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 20.

[3]The revised TQ values are calculated on Sheet 22.

Washington Closure Hanford, LLC.

Originator: T.J. Rodovsky TJR **Date:** 11/7/06 **Calc. No.:** 0100X-CA-N0020 **Rev. No.:** 1
Project: D/DR/H Field Remediation **Job No.:** 14655 **Checked:** J. D. Ludowise JDL **Date:** 11-7-06
Subject: 118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs) **Sheet No.:** 37 of 38

10.10 Soil -- Dumping, Dropping/Impact & Entrainment

Dumping & Dropping/Impact

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 $TQ_{REVISED}$ (Ci)[2]	1027 CATEGORY 3 RATIO
Ag-108m	1.35E-02	4.4E+02	3.07E-05
Am-241	1.43E-03	5.2E+02	2.76E-06
Ba-133	2.03E-04	2.0E+03	1.01E-07
C-14	1.42E-03	3.0E+03	4.75E-07
Ca-41	1.41E-05	1.6E+07	8.81E-13
Cd-113m	0.00E+00	1.2E+05	0.00E+00
Co-60	4.55E-02	2.8E+02	1.63E-04
Cs-137	1.88E-01	1.3E+03	1.44E-04
Eu-152	1.22E-03	7.0E+02	1.75E-06
Eu-154	4.27E-04	8.4E+02	5.08E-07
Eu-155	1.87E-04	1.4E+04	1.34E-08
H-3	2.72E-01	1.2E+05	2.30E-06
Kr-85	6.72E-03	2.0E+04	3.36E-07
Nb-94	4.52E-05	4.6E+02	9.83E-08
Ni-59	8.66E-03	1.2E+08	7.34E-11
Ni-63	3.23E-01	5.4E+07	5.99E-09
Pd-107	0.00E+00	4.2E+07	0.00E+00
Pu-238	7.37E-05	6.2E+02	1.19E-07
Pu-239	8.92E-05	5.2E+02	1.71E-07
Pu-240	0.00E+00	5.2E+02	0.00E+00
Pu-241	0.00E+00	3.2E+04	0.00E+00
Se-79	7.88E-04	3.6E+06	2.19E-10
Sm-151	0.00E+00	1.0E+07	0.00E+00
Sr-90	1.99E-03	1.6E+05	1.22E-08
Tc-99	1.41E-04	5.8E+03	2.43E-08
U-235	1.06E-04	4.2E+03	2.52E-08
U-238	1.08E-04	4.2E+03	2.57E-08
Zr-93	0.00E+00	6.2E+05	0.00E+00
			3.46E-04

Entrainment

Isotope	Radionuclide Inventory (Ci)[4]	1027 CATEGORY 3 $TQ_{REVISED}$ (Ci)[3]	1027 CATEGORY 3 RATIO
Ag-108m	1.35E-01	4.4E+02	3.07E-04
Am-241	1.43E-02	3.5E+04	4.14E-07
Ba-133	2.03E-03	2.0E+03	1.01E-06
C-14	1.42E-02	3.0E+03	4.75E-06
Ca-41	1.41E-04	1.1E+09	1.32E-13
Cd-113m	0.00E+00	7.7E+06	0.00E+00
Co-60	4.55E-01	2.8E+02	1.63E-03
Cs-137	1.88E+00	1.3E+03	1.44E-03
Eu-152	1.22E-02	7.0E+02	1.75E-05
Eu-154	4.27E-03	8.4E+02	5.08E-06
Eu-155	1.87E-03	1.4E+04	1.34E-07
H-3	2.72E+00	1.2E+05	2.30E-05
Kr-85	6.72E-02	2.0E+04	3.36E-06
Nb-94	4.52E-04	4.6E+02	9.83E-07
Ni-59	8.66E-02	7.9E+09	1.10E-11
Ni-63	3.23E+00	3.6E+09	8.98E-10
Pd-107	0.00E+00	2.8E+09	0.00E+00
Pu-238	7.37E-04	4.1E+04	1.78E-08
Pu-239	8.92E-04	3.5E+04	2.57E-08
Pu-240	0.00E+00	3.5E+04	0.00E+00
Pu-241	0.00E+00	2.1E+06	0.00E+00
Se-79	7.88E-03	2.4E+08	3.28E-11
Sm-151	0.00E+00	6.9E+08	0.00E+00
Sr-90	1.99E-02	1.1E+07	1.82E-09
Tc-99	1.41E-03	5.8E+03	2.43E-07
U-235	1.06E-03	5.4E+03	1.96E-07
U-238	1.08E-03	2.8E+05	3.86E-09
Zr-93	0.00E+00	4.1E+07	0.00E+00
			3.43E-03

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 1% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 25.

[3]The revised TQ values are calculated on Sheet 19.

[4]Inventory from Sheet 16 and takes into consideration 10% of inventory (Section 7.7).

Washington Closure Hanford, LLC.

Originator:	T.J. Rodovsky TJR	Date:	11/7/06	Calc. No.: 0100X-CA-N0020	Rev. No.: 1
Project:	D/DR/H Field Remediation	Job No.:	14655	Checked: J. D. Ludowise JDL	Date: 11-7-06
Subject:					Sheet No.: 38 of 38

118-D-1, 118-D-2, 118-D-3, 118-H-1, 118-H-2, and 118-H-3 Final Hazard Categorization Calculation (Revised TQs)

10.11 Combustable Materials – Entrainment

Isotope	Radionuclide Inventory (Ci)[1]	1027 CATEGORY 3 $TQ_{REVISED}$ (Ci)[2]	RATIO
Ag-108m	4.80E-02	4.4E+02	1.09E-04
Am-241	5.09E-03	1.0E+00	4.89E-03
Ba-133	7.20E-04	2.0E+03	3.60E-07
C-14	5.05E-03	3.0E+03	1.68E-06
Ca-41	5.00E-05	3.2E+04	1.56E-09
Cd-113m	0.00E+00	2.3E+02	0.00E+00
Co-60	1.61E-01	2.8E+02	5.76E-04
Cs-137	6.66E-01	1.2E+03	5.55E-04
Eu-152	4.34E-03	7.0E+02	6.20E-06
Eu-154	1.51E-03	8.4E+02	1.80E-06
Eu-155	6.65E-04	1.4E+04	4.75E-08
H-3	9.64E-01	1.2E+05	8.17E-06
Kr-85	2.38E-02	2.0E+04	1.19E-06
Nb-94	1.60E-04	4.6E+02	3.49E-07
Ni-59	3.07E-02	2.4E+05	1.30E-07
Ni-63	1.15E+00	1.1E+05	1.06E-05
Pd-107	0.00E+00	8.4E+04	0.00E+00
Pu-238	2.61E-04	1.2E+00	2.11E-04
Pu-239	3.16E-04	1.0E+00	3.04E-04
Pu-240	0.00E+00	1.0E+00	0.00E+00
Pu-241	0.00E+00	6.4E+01	0.00E+00
Se-79	2.80E-03	7.2E+03	3.88E-07
Sm-151	0.00E+00	2.1E+04	0.00E+00
Sr-90	7.07E-03	3.3E+02	2.16E-05
Tc-99	4.99E-04	5.8E+03	8.61E-08
U-235	3.76E-04	8.4E+00	4.47E-05
U-238	3.83E-04	8.4E+00	4.56E-05
Zr-93	0.00E+00	1.2E+03	0.00E+00
			6.79E-03

Calculations

RATIO (CATEGORY 3) = EI/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Inventory from Sheet 16 and takes into consideration 10% of inventory (Section 7.7).

[2]The revised TQ values are calculated on Sheet 23.

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